



**Barcelona
Supercomputing
Center**
Centro Nacional de Supercomputación



Modeling the dust cycle at BSC

From R&D to operational forecast

Sara Basart (sara.basart@bsc.es)

C. Pérez García-Pando, O. Jorba, E. Di Tomaso, L. Vendrell, E. Terradellas, G. García-Castrillo, F. Benincasa and K. Serradell

6th Dust Training, 25-27 October 2017, Istanbul

BSC Earth Sciences Department

What

Environmental modelling and forecasting

How

Develop a capability to model air quality processes from urban to global and the impacts on weather, health and ecosystems

Implement climate prediction system for subseasonal-to-decadal climate prediction

Develop user-oriented services that favour both technology transfer and adaptation

Use cutting-edge HPC and Big Data technologies for the efficiency and user-friendliness of Earth system models

Why

Our strength ...

... research ...

... operations ...

... services ...

... high resolution ...



*MareNostrum
supercomputer*

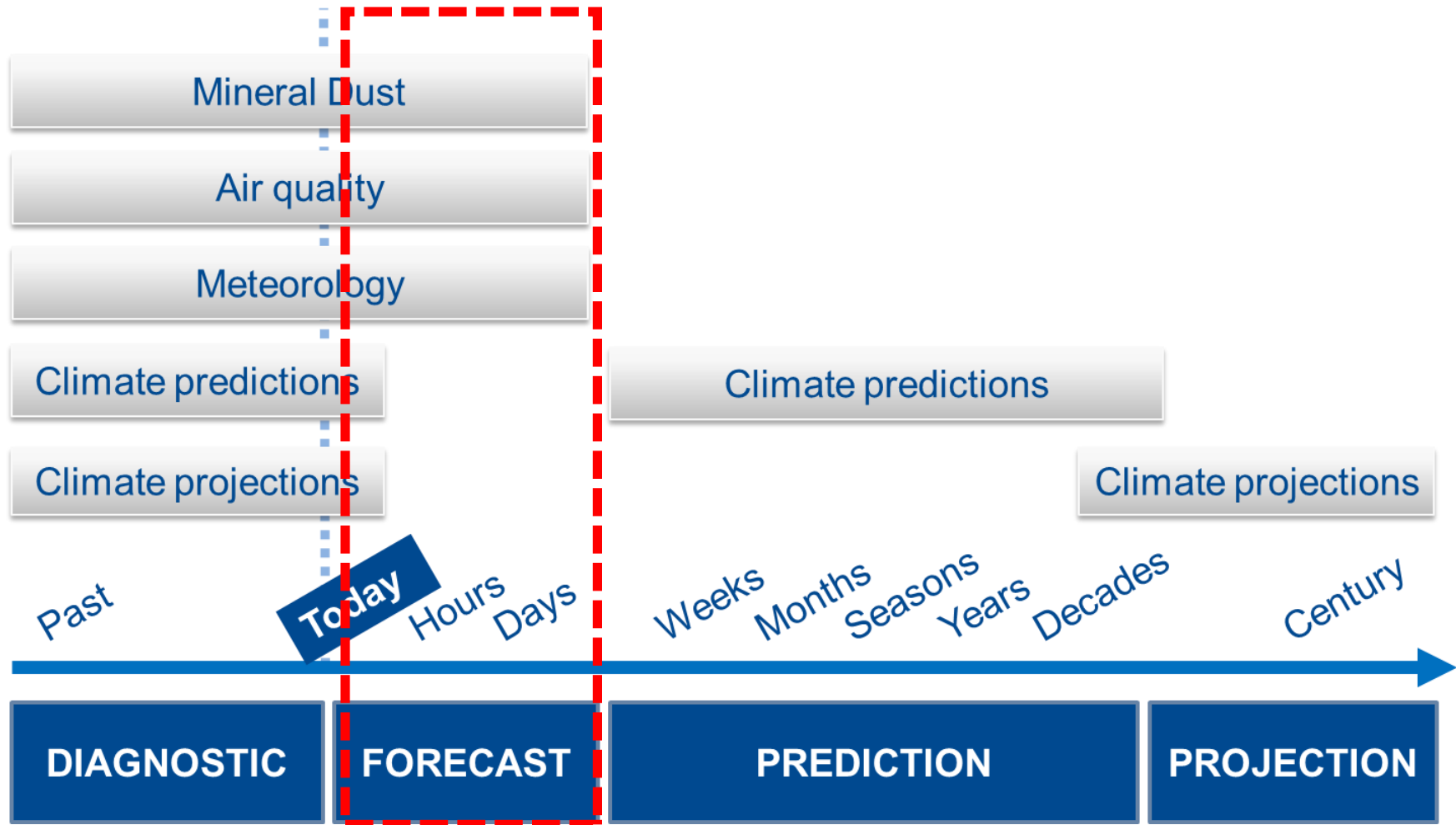
Earth system
services

Climate
prediction

Atmospheric
composition

Computational
Earth sciences

BSC Earth Sciences Department



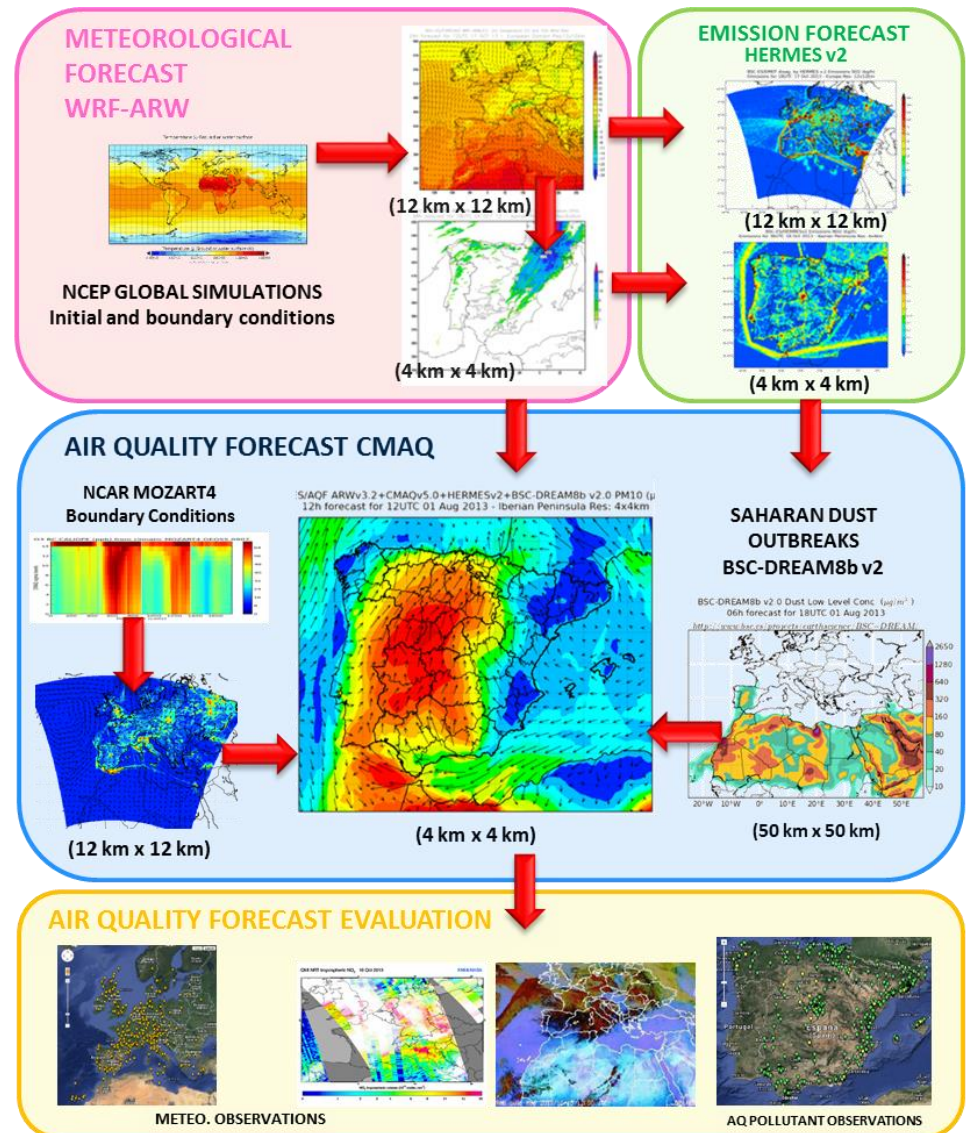
Air Quality Modelling

CALIOPE (www.bsc.es/caliope)

- Quantify relation between emissions, meteorology and air concentration
- Forecast air pollution episodes
- Provide and develop short and long term mitigation plans

Domains:

Europe (12 km, 480 x 400 cells)
Spain (4 km, 399 x 399 cells)



CONSEJERÍA DE MEDIO AMBIENTE
Y ORDENACIÓN DEL TERRITORIO



GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN
Y MEDIO AMBIENTE



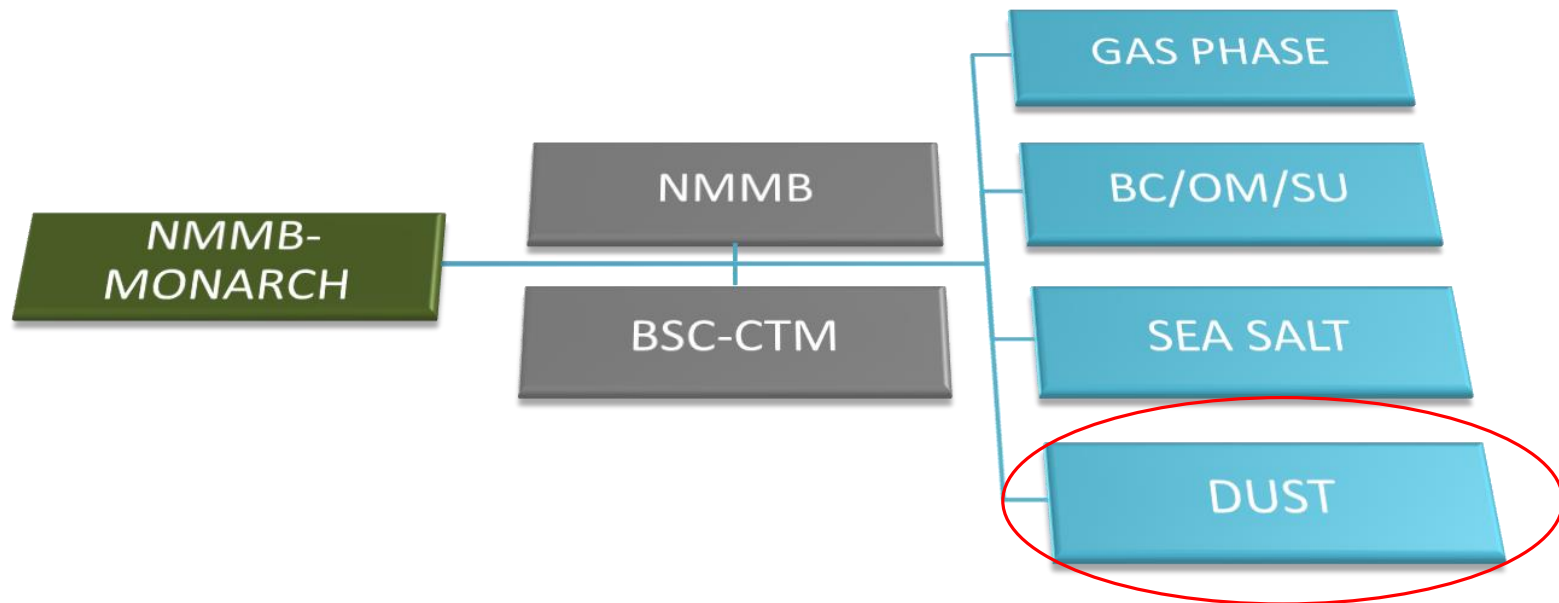
Consejería de Educación,
Universidades y Sostenibilidad



Generalitat de Catalunya
Departament de Territori
i Sostenibilitat

Atmospheric Composition modelling: NMMB-MONARCH

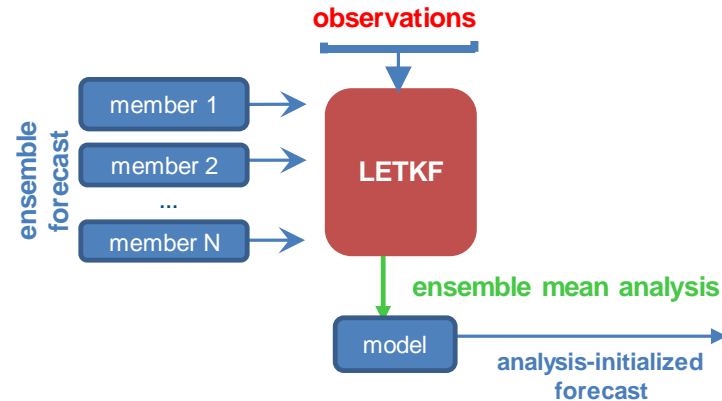
- The main system is build on the **meteorological driver NMMB**
- **Multiscale**: global to regional scales allowed (nesting capabilities)
- **Nonhydrostatic** dynamical core: single digit kilometre resolution allowed
- Fully **on-line** coupling: weather-chemistry feedback processes allowed
- Enhancement with a **data assimilation** system



Known as **NMMB/BSC-Dust**

NMMB-MONARCH: Data Assimilation

NMMB-MONARCH coupled with a Local Ensemble Transform Kalman Filter (**LETKF**) for the assimilation of aerosol optical depth observations

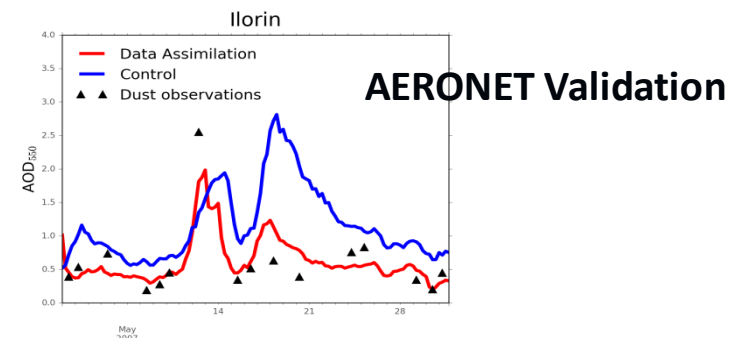
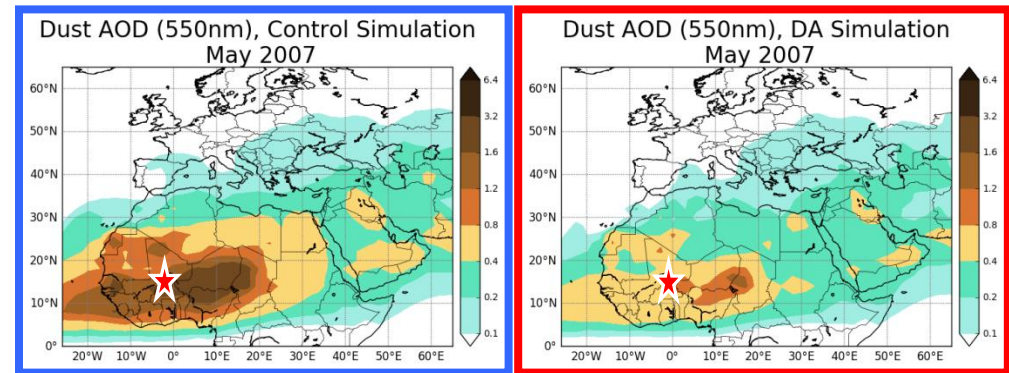


Mineral dust application

The ensemble forecast is based on uncertainties in the dust emission scheme

- vertical flux,
- size distribution at emission
- threshold on friction velocity

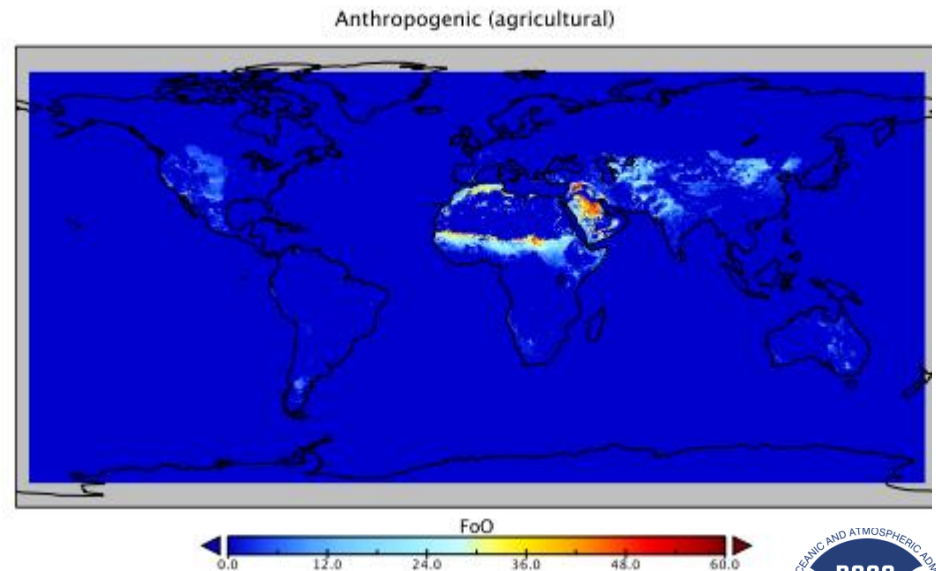
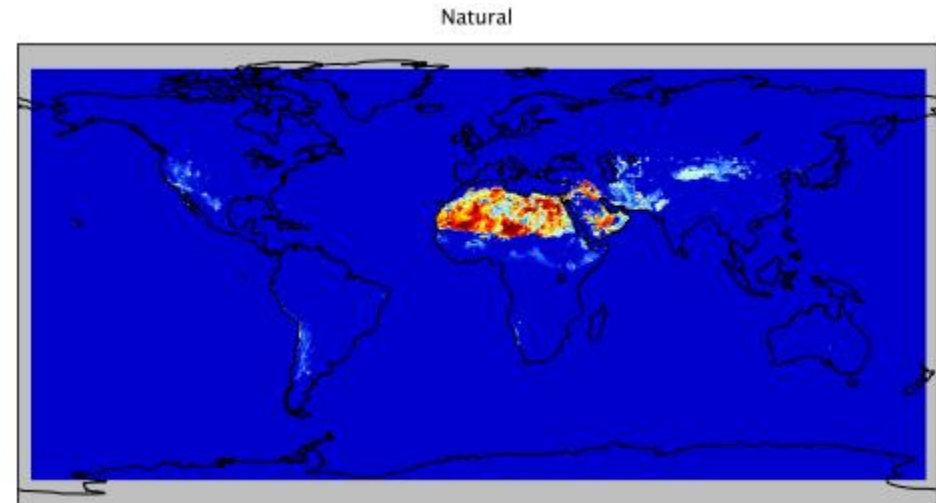
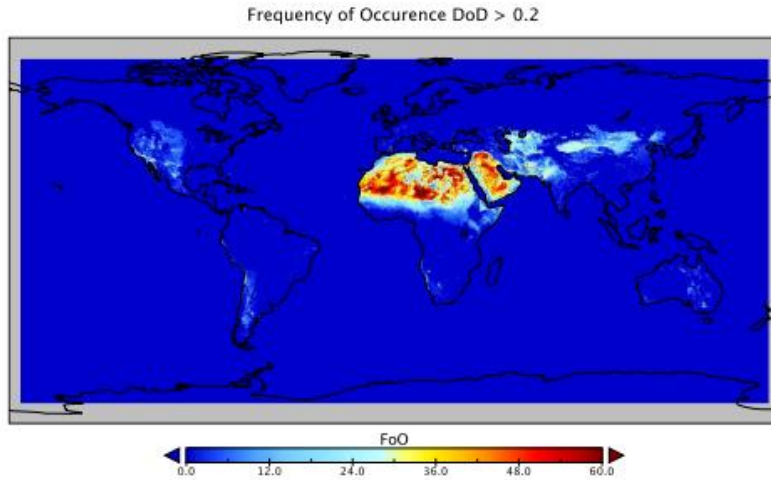
(DiTomaso et al., GMD, 2016)



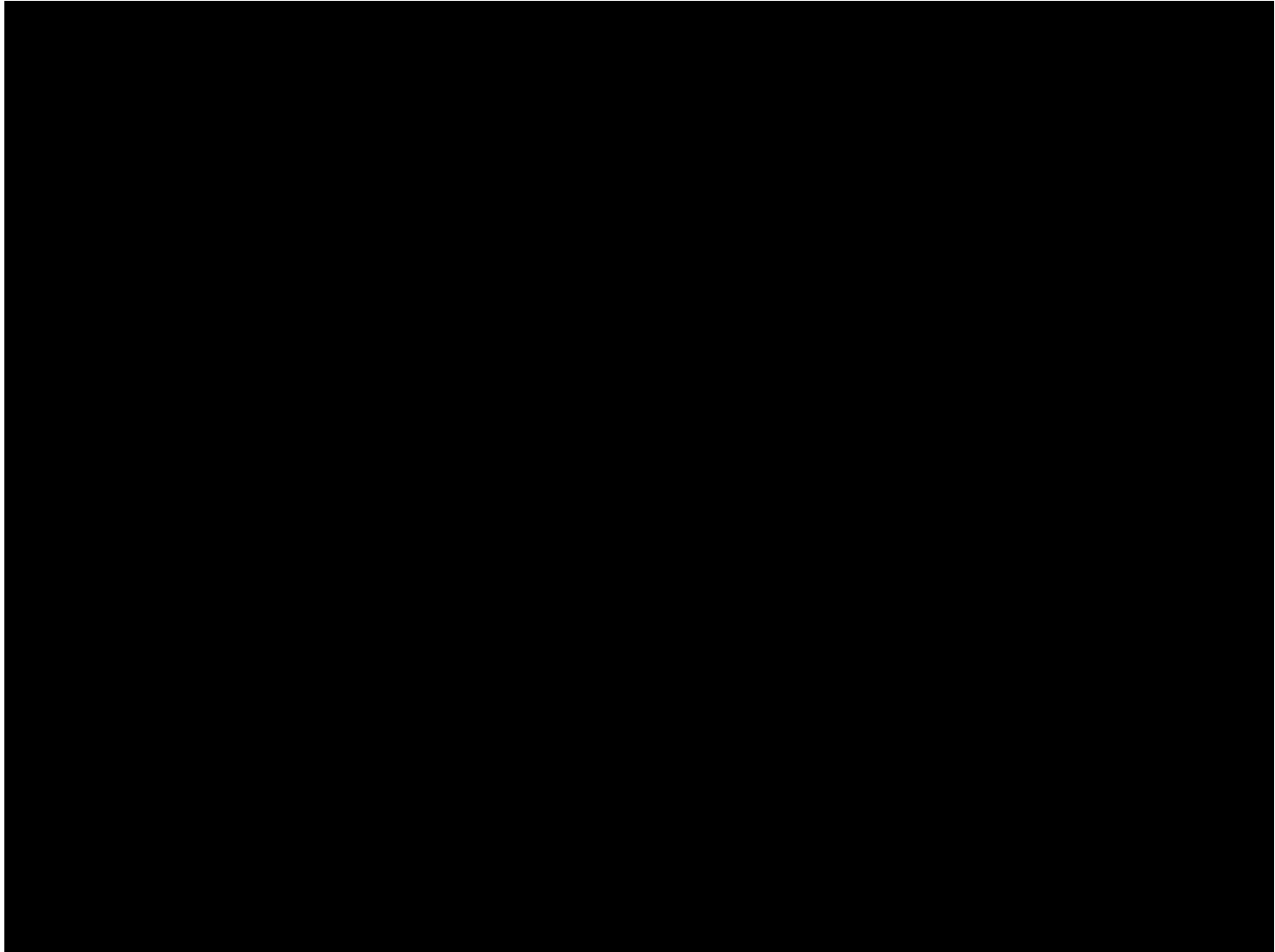
Mineral Dust modelling: Dust sources

Understanding of the mineral dust sources

Natural and anthropogenic
based on MODIS Deep



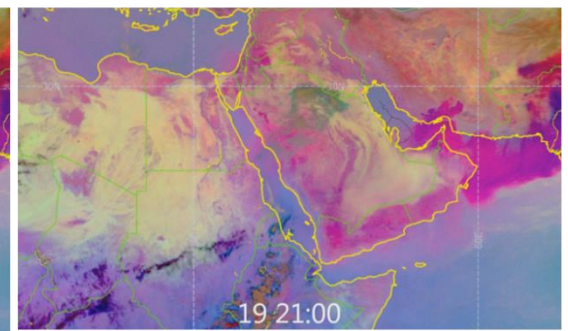
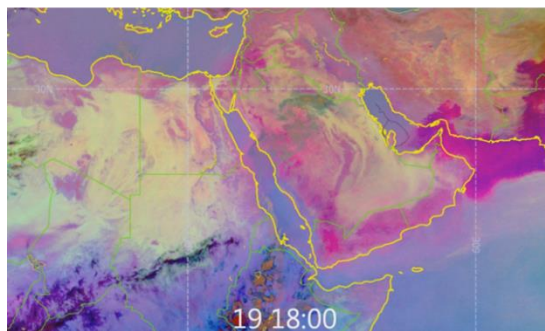
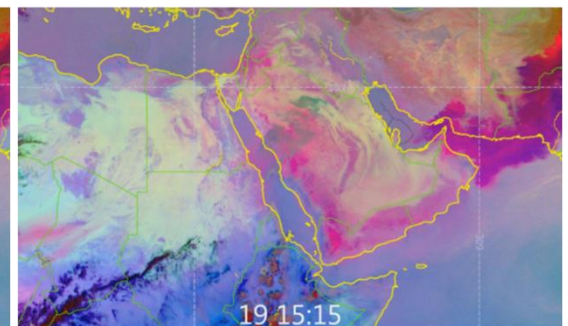
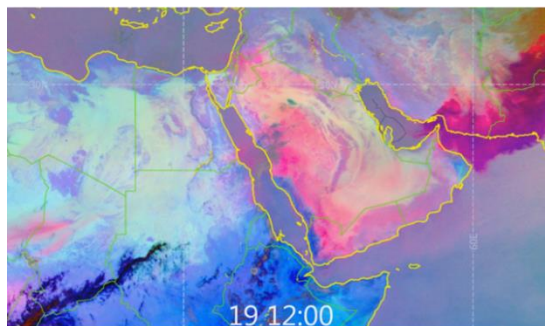
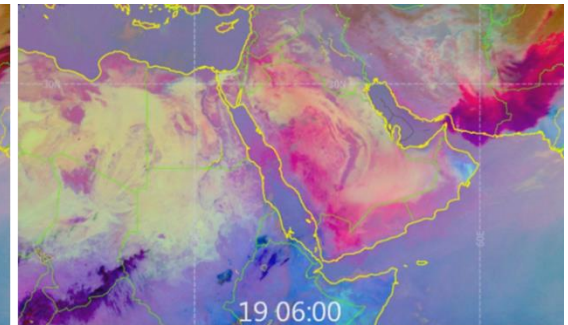
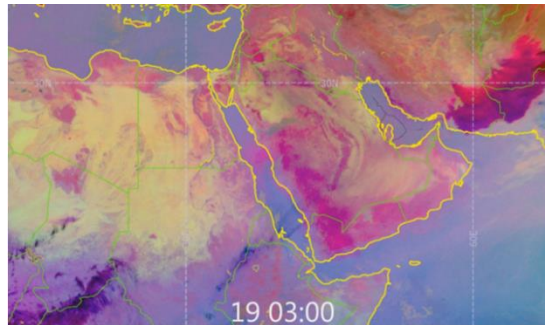
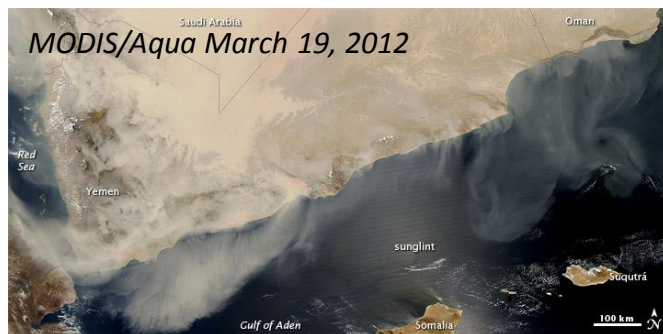
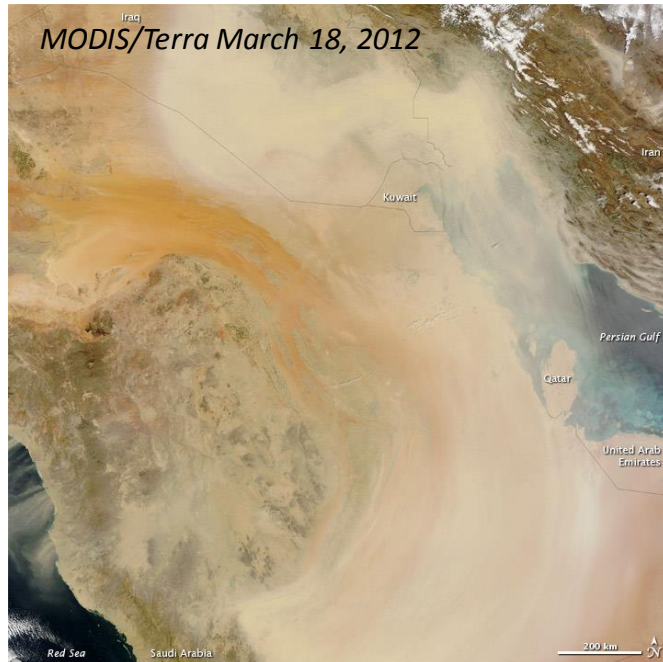
Mineral Dust modelling: Topography



Mineral Dust modelling: Topography

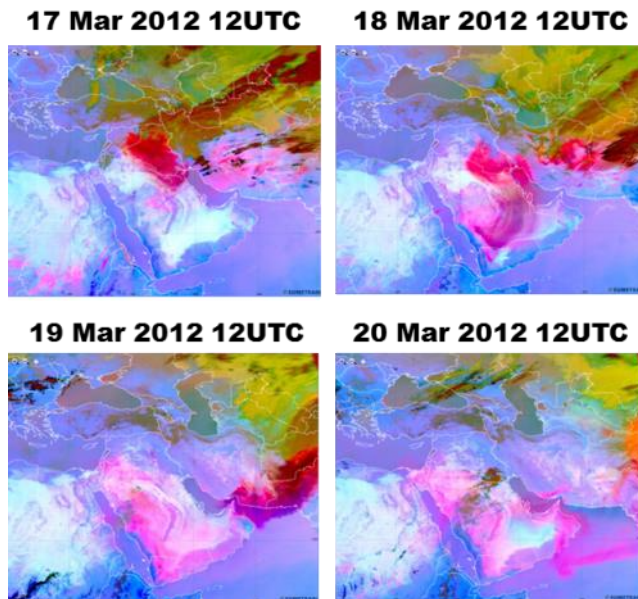
Impact of the topography on dust transport

MSG/RGB March 19, 2012



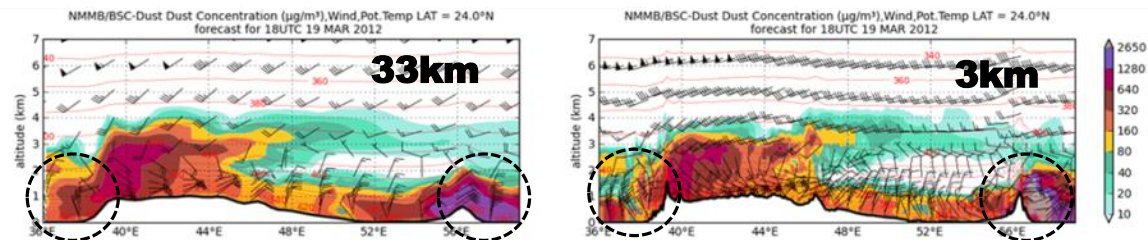
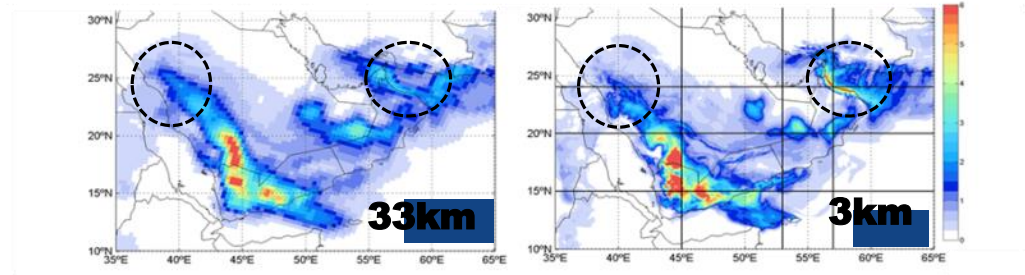
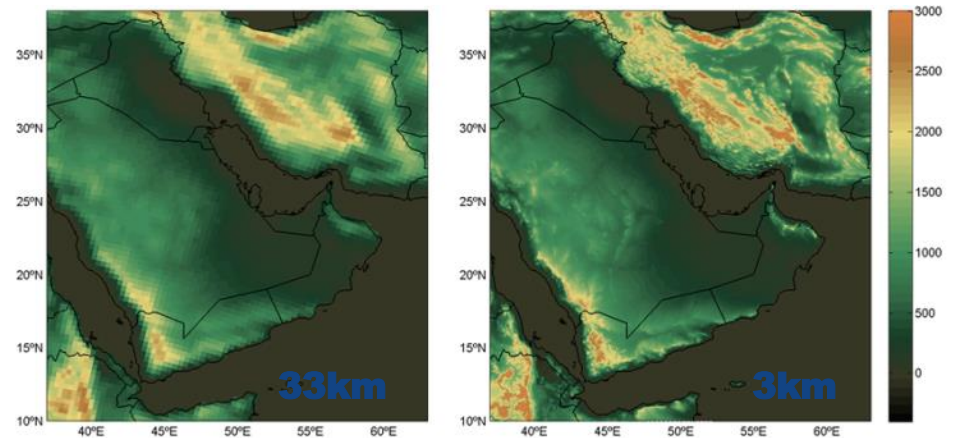
(Basart et al., Aeolian Research, 2016)

Mineral Dust modelling: Topography



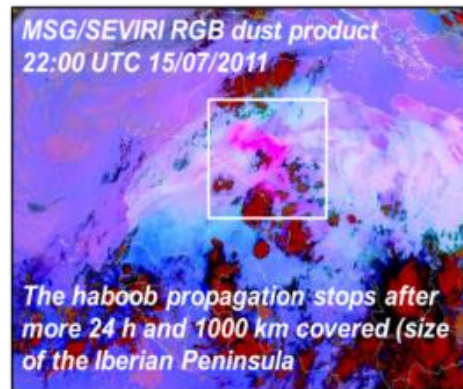
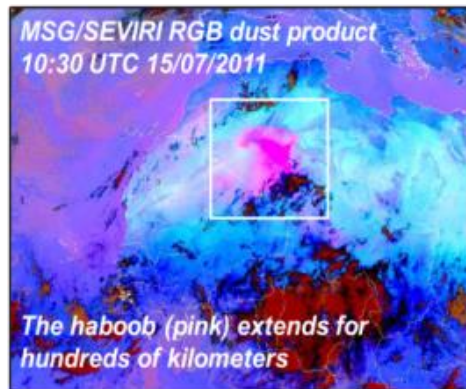
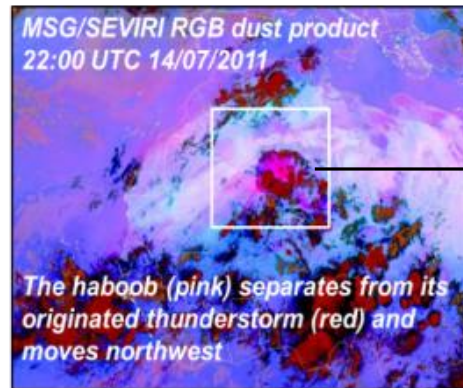
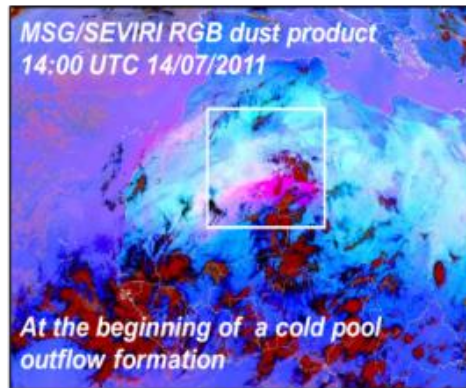
Two simulations using the **NMMB/BSC-Dust** model demonstrates results demonstrate how the dust prediction in the vicinity of complex terrains improves using high-horizontal resolution simulations.

NMMB/BSC-Dust 19-March-2012 18UTC



(Basart et al., Aeolian Research, 2016)

Mineral Dust modelling: Haboobs



MODEL CONFIGURATION

Study domain: 6°W-10°E to 15°N-31°N

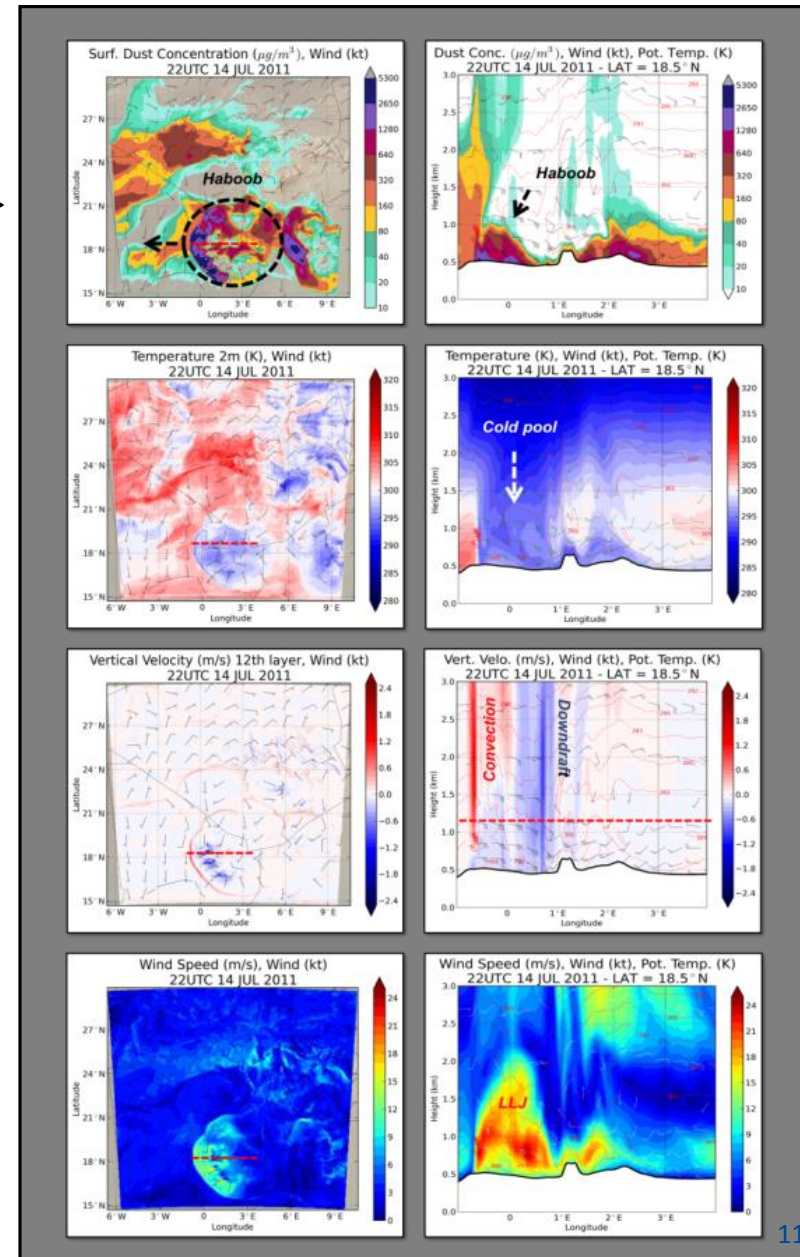
Study period: from 14 to 15 July 2011

Horizontal resolution: 0.03°x0.03° (about 3 km) → **allowing explicit convection**

Vertical resolution: 60σ-layers (12-15σ-layers in the first 1000 m)

Cold start (No data assimilation)

(Vendrell et al., in preparation)

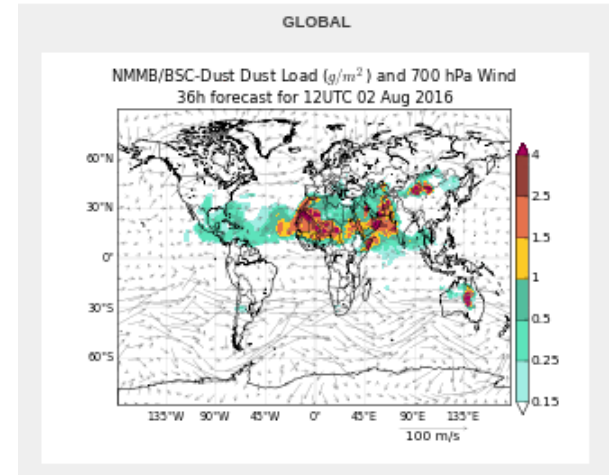


Mineral dust Services

BSC dust operational forecast (global and regional domains)

<http://www.bsc.es/ESS>

✓ Contribution to the **ICAP** multi-model ensemble (global) <http://icap.atmos.und.edu>



WMO Dust Centers

SDS-WAS. North Africa, Middle East and Europe

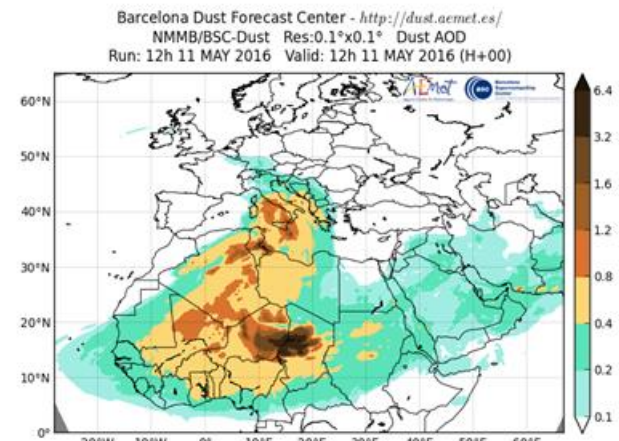
Regional Center. <http://sds-was.aemet.es>

started in 2010 – **Research**

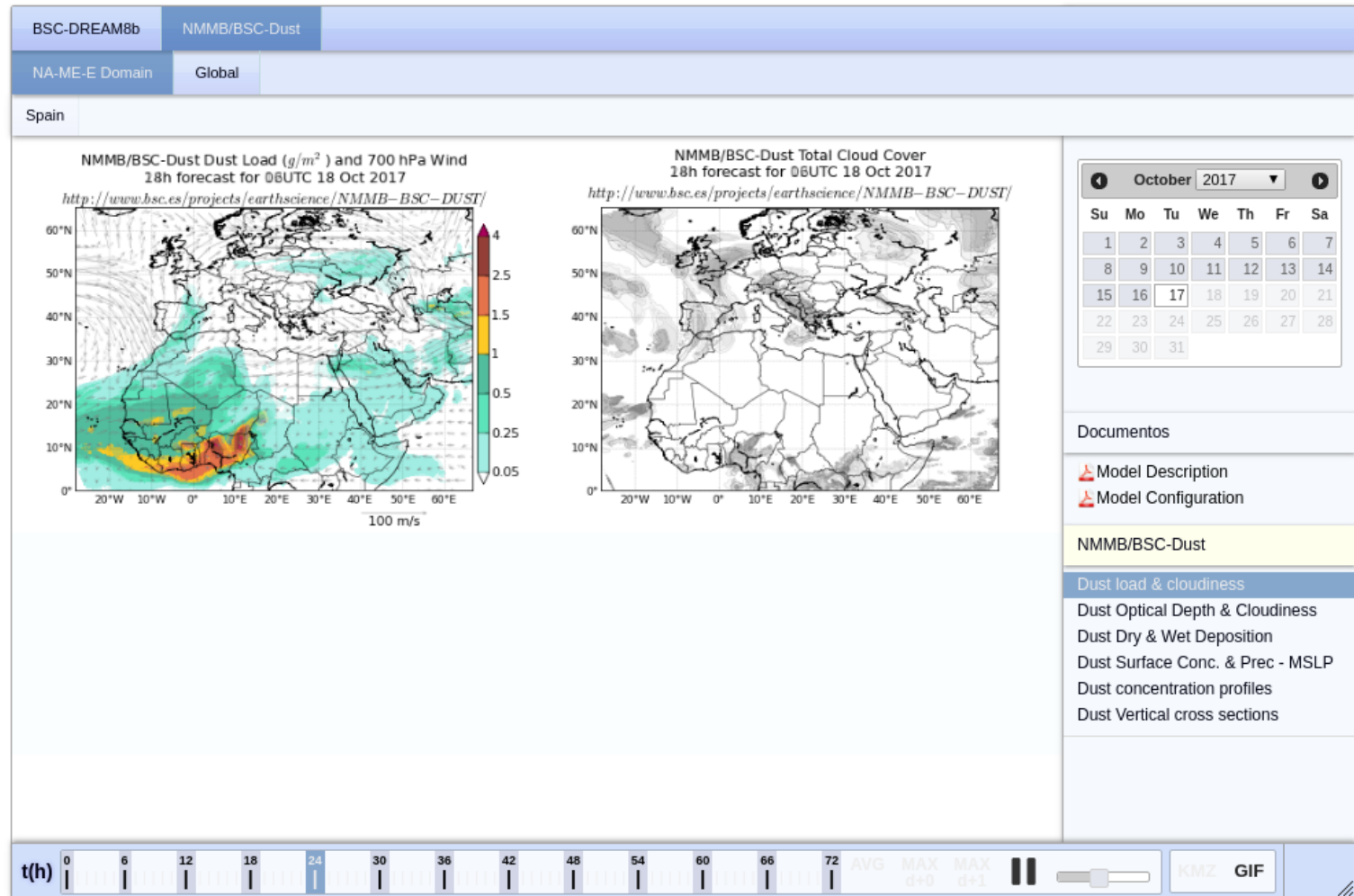
Barcelona Dust Forecast Center.

First specialized WMO Center for mineral dust prediction.

<http://dust.aemet.es> started in 2014 - **Operational**

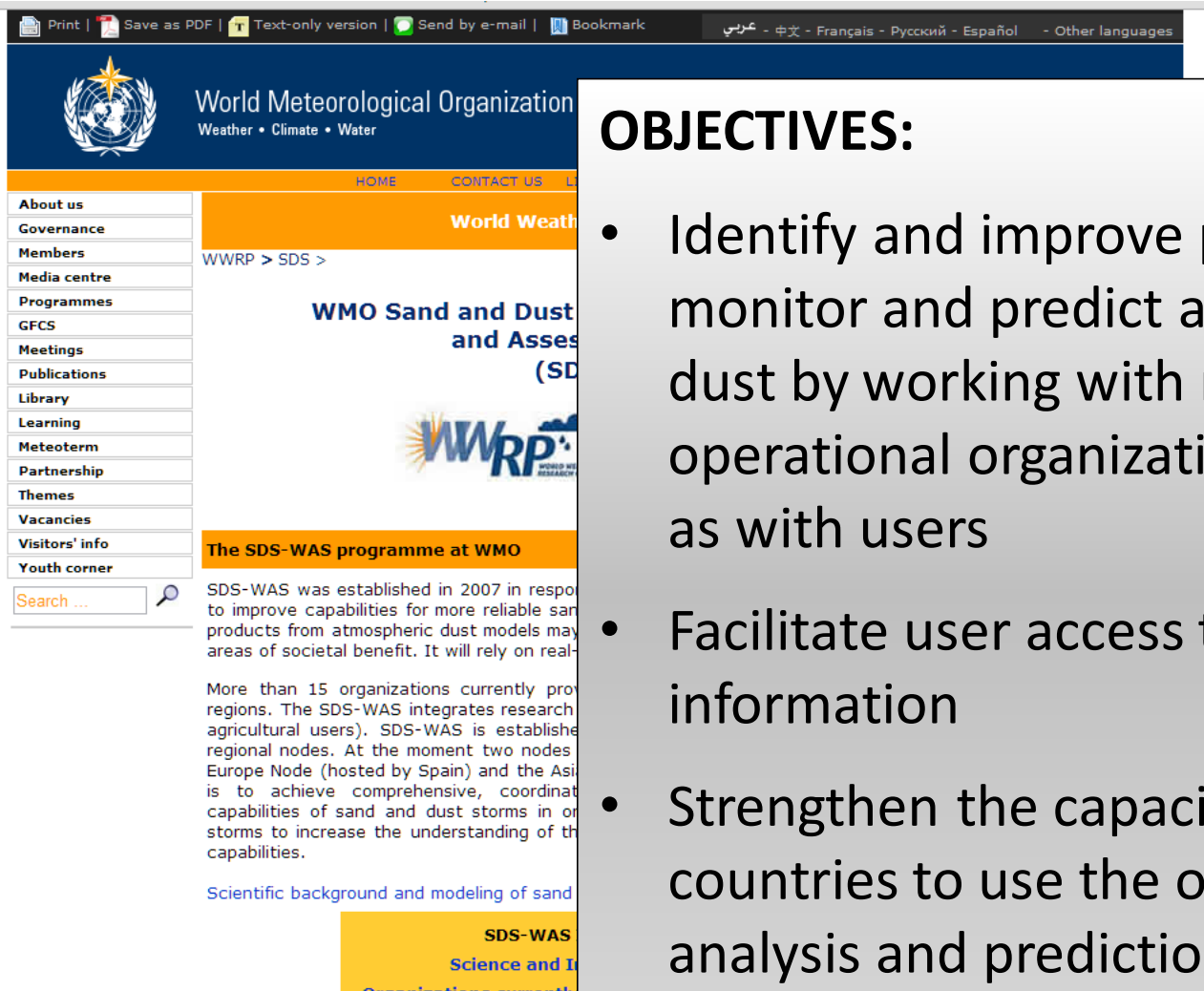


BSC dust operational forecast



<http://www.bsc.es/ESS>

The WMO SDS-WAS project



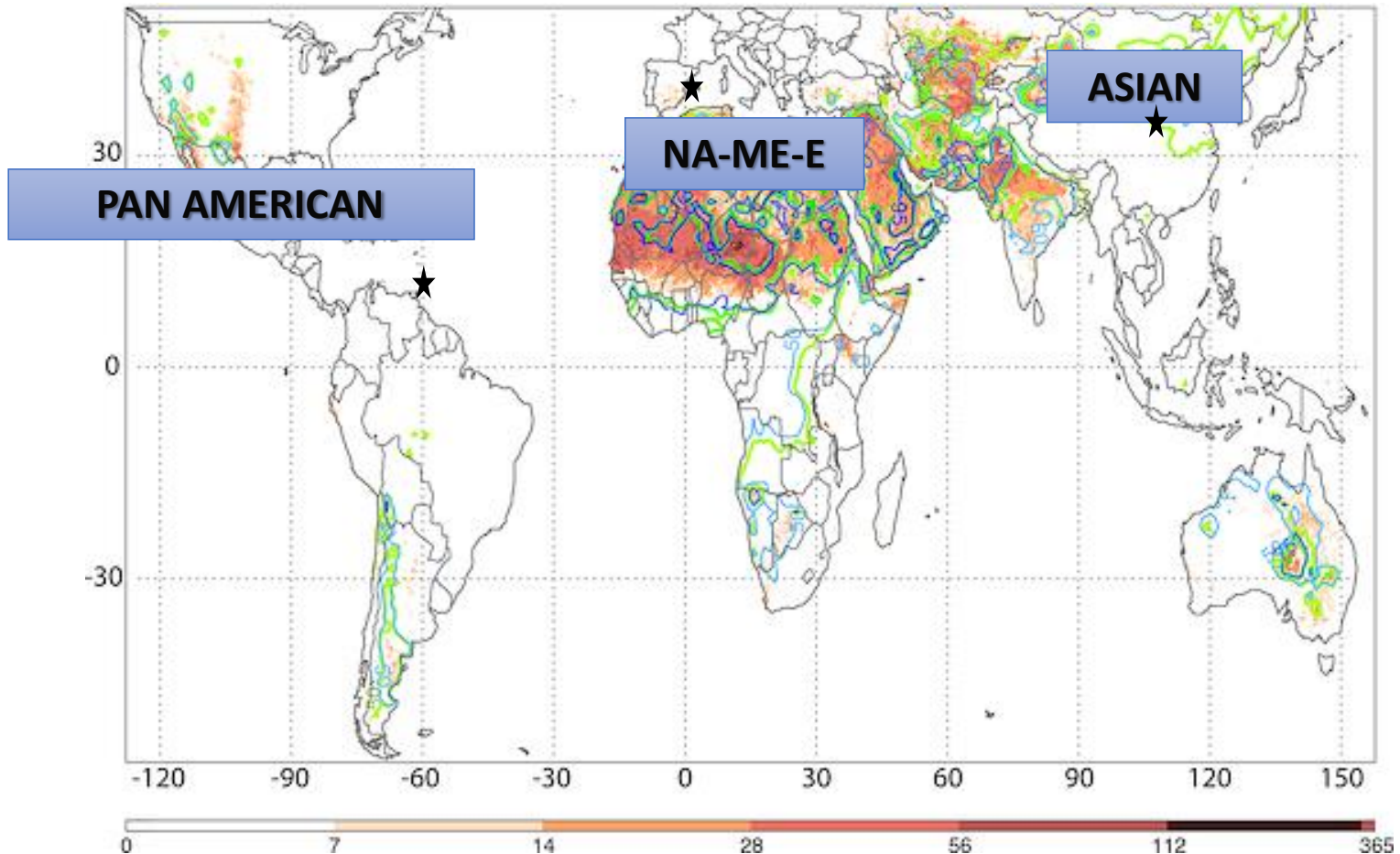
The screenshot shows the WMO website with the following elements:

- Header:** WMO logo, "World Meteorological Organization", "Weather • Climate • Water", and a language menu (عربي - 中文 - Français - Русский - Español - Other languages).
- Navigation:** HOME, CONTACT US, and a sidebar menu with links like About us, Governance, Members, Media centre, Programmes, GFCS, Meetings, Publications, Library, Learning, Meteoterm, Partnership, Themes, Vacancies, Visitors' info, and Youth corner.
- Breadcrumbs:** WWRP > SDS >
- Section Header:** "WMO Sand and Dust and Assessment (SD)" with a WWRP logo.
- Section Title:** "The SDS-WAS programme at WMO".
- Text:** "SDS-WAS was established in 2007 in response to improve capabilities for more reliable sand products from atmospheric dust models may areas of societal benefit. It will rely on real-".
- Text:** "More than 15 organizations currently provide data from various regions. The SDS-WAS integrates research and operational users). SDS-WAS is established regional nodes. At the moment two nodes: Europe Node (hosted by Spain) and the Asia Node (hosted by India) are operational. The goal is to achieve comprehensive, coordinated capabilities of sand and dust storms in order to increase the understanding of the capabilities."
- Text:** "Scientific background and modeling of sand and dust storms".
- Text:** "SDS-WAS Science and Information Systems".

OBJECTIVES:

- Identify and improve products to monitor and predict atmospheric dust by working with research and operational organizations, as well as with users
- Facilitate user access to information
- Strengthen the capacity of countries to use the observations, analysis and predictions provided by the WMO SDS-WAS project

The SDS-WAS Regional Centers



Annual mean frequency distribution of M-DB2 (2003–2009) DOD > 0.2 (red), TOMS (1980–1991) aerosol index ≥ 0.5 (blue), and OMI (2004–2006) aerosol index ≥ 0.5 (green). The isocontours of TOMS and OMI have been removed over oceans for clarity.

SDS-WAS Asian RC

WMO Sand and Dust Storm Warning Advisory and Assessment System(WMO SDS-WAS)
ASIA/CENTRAL PACIFIC REGIONAL CENTRE

Home Forecast Observation Model InterComparison News & Event Publications About us

FORECAST

Concentration
Movies of surface dust concentration distribution over Asia in 3 hours interval for 3 days forecast from the model CUACE/Dust. [see more>>](#) [MORE](#)

CUACE/DUST OF CMA [see more>>](#) [MORE](#)

MASINGAR OF JMA [see more>>](#) [MORE](#)

ADAM OF KMA [see more>>](#) [MORE](#)

News & Event

- Severe Solar Blast Affects China's Communication
- Science Steering Committee
- Workshop on the Implementation of the WMO SDS-WAS Asia Node (28-30 October 2009, Seoul, Korea)
- Workshop on the Implementation of the WMO SDS-WAS Asia Node

OBSERVATION

PM10

CMA JMA KMA Other

AOD

CMA JMA KMA Other

Satellite Observation

CMA JMA KMA Other

MODEL COMPARISON

Model InterComparison
To promote the SDS forecast ability and to evaluate SDS forecast models representation in Asia Regional Center, one of the most important activities is model inter-comparison. At present there are three operational forecast models CUACE/Dust...

LOGIN

username
password
checking
0999
[Login](#) [Register](#)

SDS COLOR INDEX

No SDS
Suspended dust
Blowing sand
Sand And Dust Storm
Severe SDS
Extreme Severe SDS

HOT LINKS

- CMA
- WMO SDS WAS
- CA WAS
- CAMS
- NAMC regional center

FORECAST DATA SHARING

Download Forecast Data from

Only works during Spring!

SDS-WAS Pan-American RC



WMO Sand and Dust Storm Warning Advisory
and Assessment System (SDS-WAS)
Pan-American Regional Center

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WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) Pan-American Regional Center

Enhancing the ability of countries to deliver timely and quality sand and dust storm forecasts, observations, information and knowledge to users through an international partnership of research and operational communities.



<http://sds-was.cimh.edu.bb/>

SDS-WAS NAMEE RC

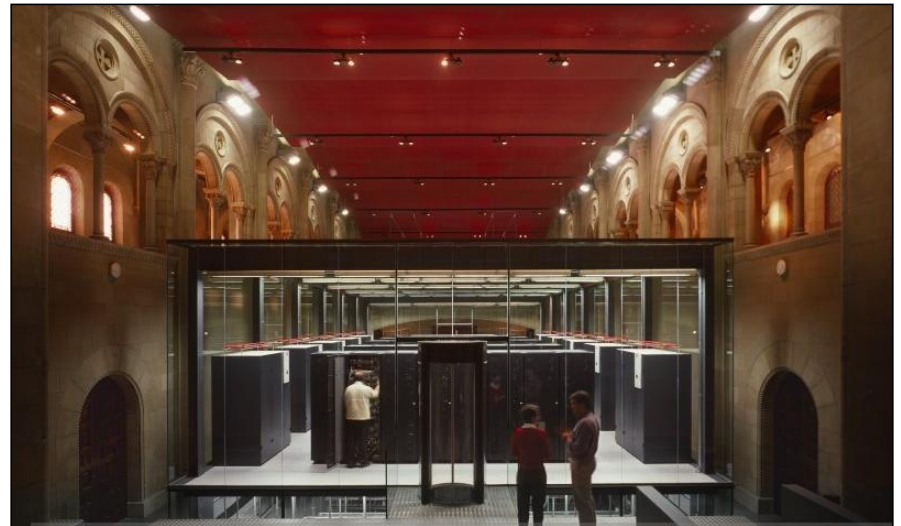
The Center is managed by a consortium of AEMET and the Barcelona Supercomputing Center (BSC-CNS)




Nexus II Building. Barcelona



MareNostrum supercomputer



SDS-WAS NAMEE RC



NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)





WMO SDS WAS || Asia Regional Center || America Regional Center

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Northern Africa-Middle East-Europe (NA-ME-E) Regional Center

by Francisco Botinca — last modified May 25, 2012 03:33 PM

Outstanding

[Addressing Sand and Dust Storms in Sustainable Development Goals Implementation](#)

[WMO supports the International Conference on sand and dust storms currently held in Tehran](#)

[SDS-WAS will contribute to UN Conference on sand and dust storms to be held in Tehran](#)

[New members of the SDS-WAS Regional Steering Group for Northern Africa, Middle East and Europe](#)

[6th Training Course on WMO SDS-WAS Products \(Satellite and Ground Observation and Modelling of Atmospheric Dust\)](#)

Subscribe to the Public Newsletter!

To be informed about our activities, news and events related to dust. Frequency is almost monthly.

Portal manual

Please find a brief manual [here](#).

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- Projects & Research
- Materials
- News
- Events

Search

Latest News

[Atmosphere. Special issue "Studying the effects of dust on weather"](#)
Oct 20, 2017

[Impact of dust deposition on wheat production](#)
Oct 19, 2017

[Paper on the pulsating nature of large-scale Saharan dust transport](#)
Oct 17, 2017

Upcoming Events

[International Workshop on Middle East \(Regional\) Dust Sources and Their Impacts](#)
Oct 23, 2017 - Oct 25, 2017 — Istanbul, Turkey

Dust forecasts



Compared Dust Forecasts



Forecast Evaluation

SDS-WAS NAMEE: Dust Forecasts

Dust prediction models provide 72 hours (at 3-hourly basis) of dust forecast (AOD at 550nm and surface concentration) covering the NAMEE region.



MODEL	RUN TIME	DOMAIN	DATA ASSIMILATION
BSC-DREAM8b	12	Regional	No
CAMS ECMWF	00	Global	MODIS AOD
DREAM8-NMME	00	Regional	CAMS analysis
NMMB/BSC-Dust	00	Regional	No
MetUM	12	Global	MODIS AOD
GEOS-5	00	Global	MODIS reflectances
NGAC	00	Global	No
RegCM4 EMA	00	Global	No
DREAMABOL	12	Regional	No
WRF-CHEM NOA	12	Regional	No
SILAM	12	Regional	No
LOTOS-EUROS	12	Regional	No

SDS-WAS NAMEE: Files Download

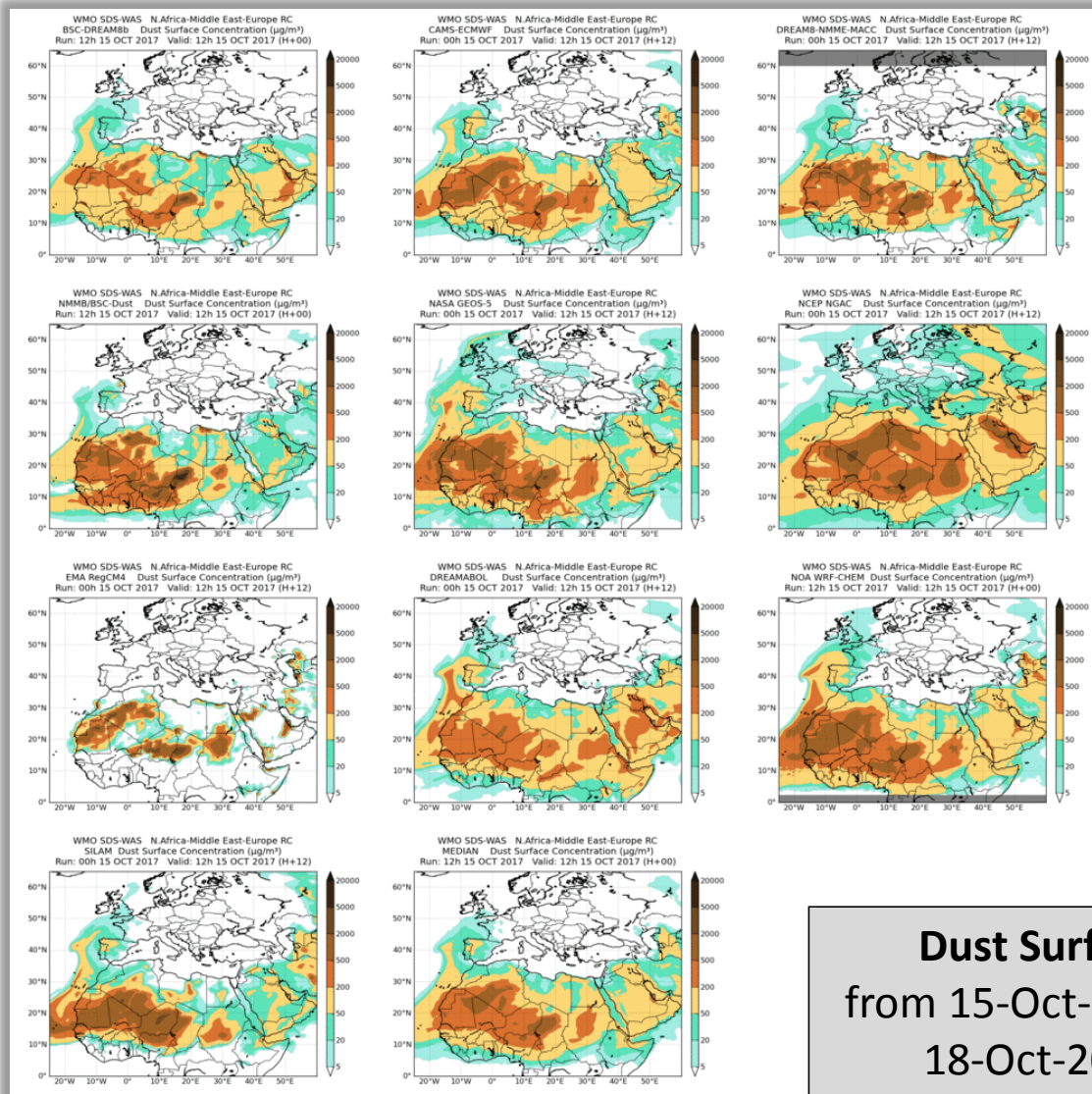
BSC-DREAM8b v2.0	PUBLIC Files RESTRICTED Files	Model website	
CAMS-ECMWF	PUBLIC Files RESTRICTED Files	Model website	
DREAM-NMME-MACC	PUBLIC Files RESTRICTED Files	Model website	

NMMB/BSC-I			
NASA-GEOS-1	latest - <i>(download all)</i>	4.0 kB	Oct 19, 2017 10:40 PM
NCEP-NGAC	2017 - <i>(download all)</i>	4.0 kB	Oct 03, 2017 10:40 PM
	2016 - <i>(download all)</i>	4.0 kB	Dec 03, 2016 10:40 PM
DREAMABOI	2015 - <i>(download all)</i>	4.0 kB	Mar 07, 2016 12:49 PM
	2014 - <i>(download all)</i>	4.0 kB	Mar 07, 2016 12:49 PM
EMA-RegCM4	2013 - <i>(download all)</i>	4.0 kB	Mar 07, 2016 12:49 PM
	2012 - <i>(download all)</i>	4.0 kB	Mar 07, 2016 12:49 PM

- Daily forecasts of dust surface concentration and dust optical depth will be displayed on a page together with a menu to allow visualization of the archived products and/or download of the numerical files for a selected range of dates.
- Access to the download pages shall be restricted to those groups that authorize the exchange of their own data.

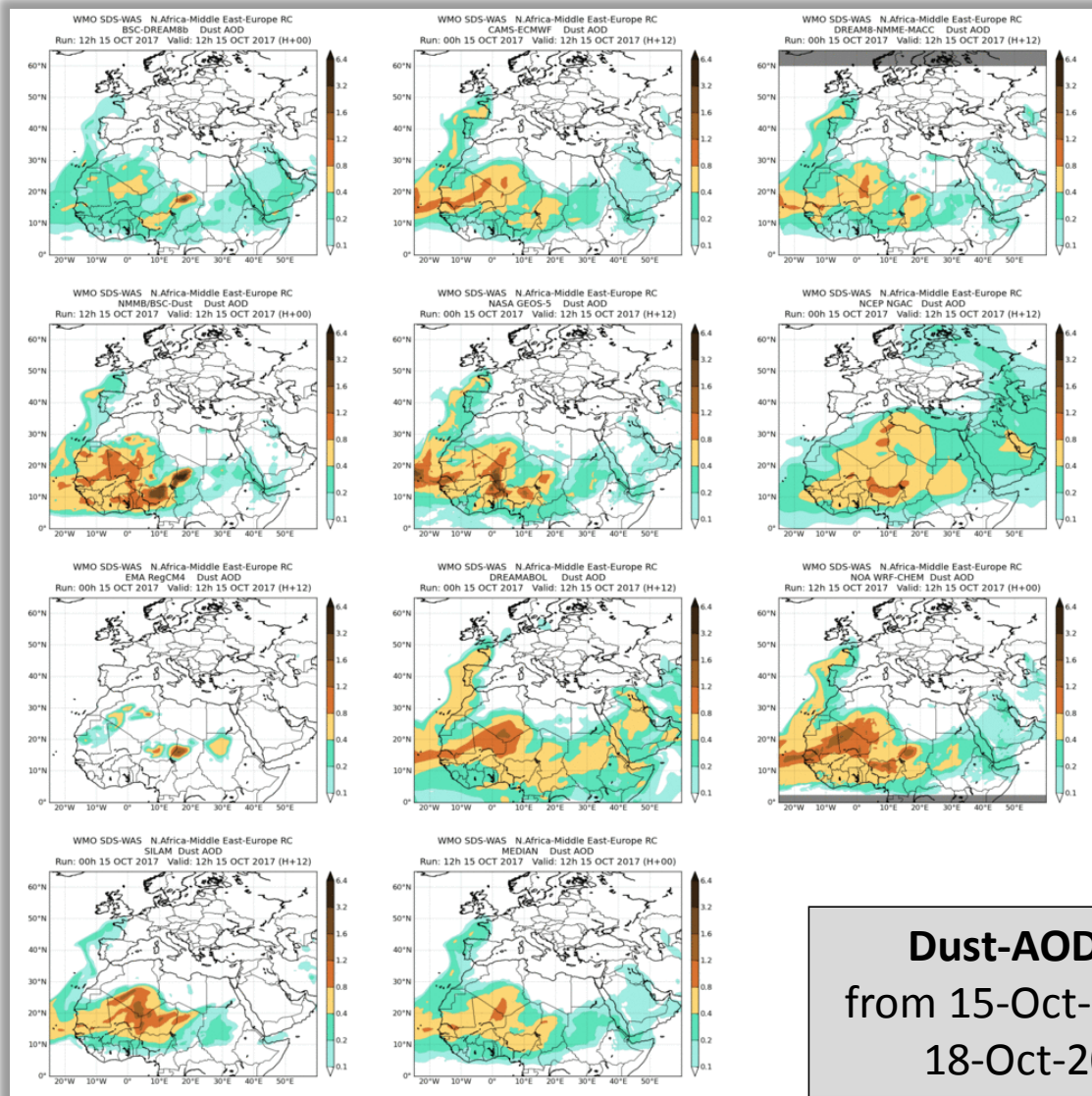
Needed registered user!

SDS-WAS NAMEE: Joint Visualization



Dust Surface Conc.
from 15-Oct-2017 12:00 to
18-Oct-2017 00:00

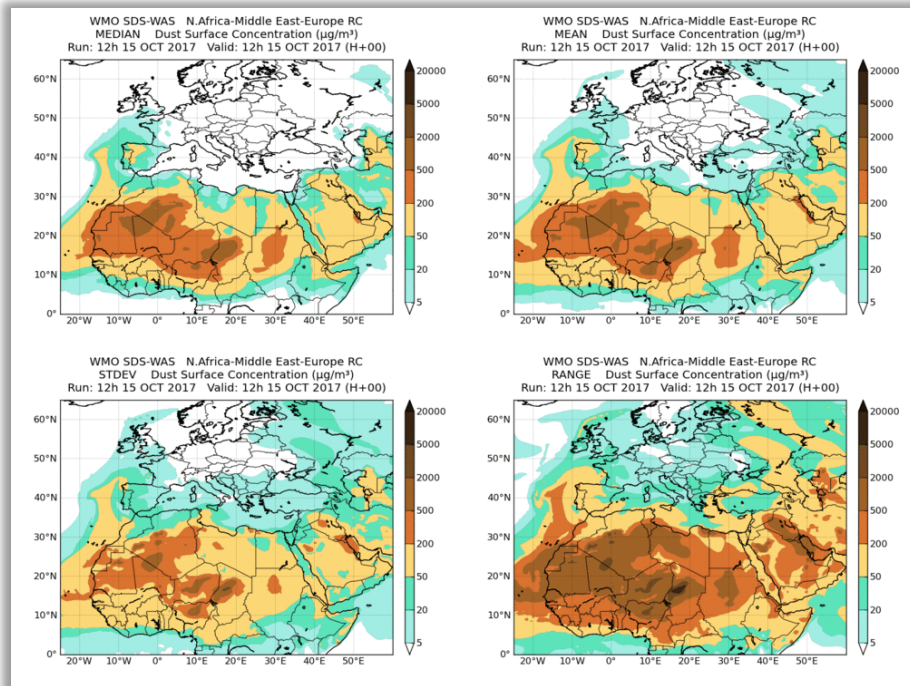
SDS-WAS NAMEE: Joint Visualization



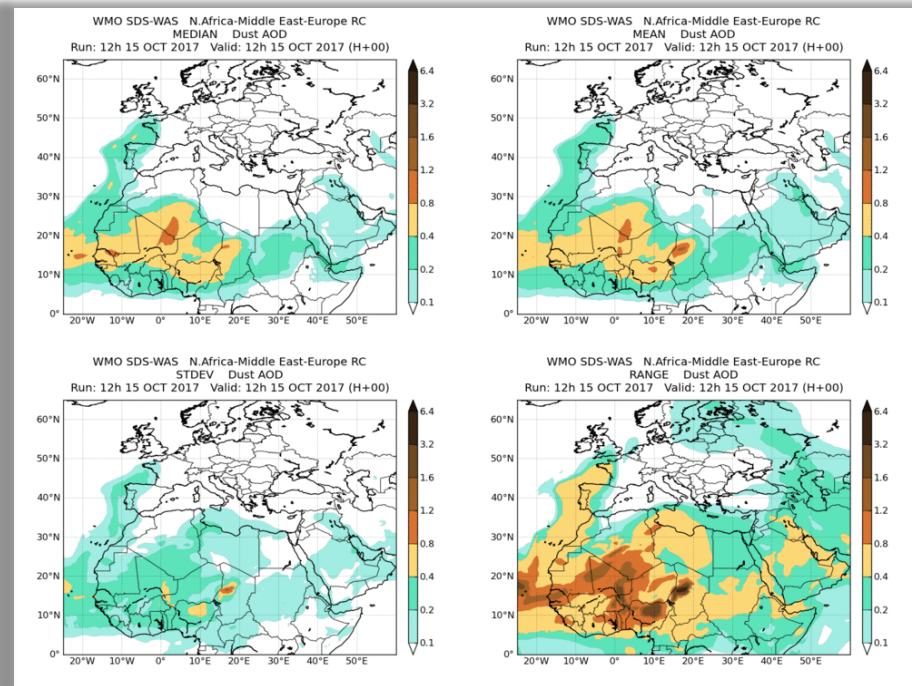
Dust-AOD at 550nm
from 15-Oct-2017 12:00 to
18-Oct-2017 00:00

SDS-WAS NAMEE: Multi-model

Surface concentration



Dust AOD at 550nm



from 15-Oct-2017 12:00 to 18-Oct-2017 00:00

Model outputs are bi-linearly interpolated to a common $0.5^\circ \times 0.5^\circ$ grid mesh. Then, different multi-model products are generated:

CENTRALITY: median - mean

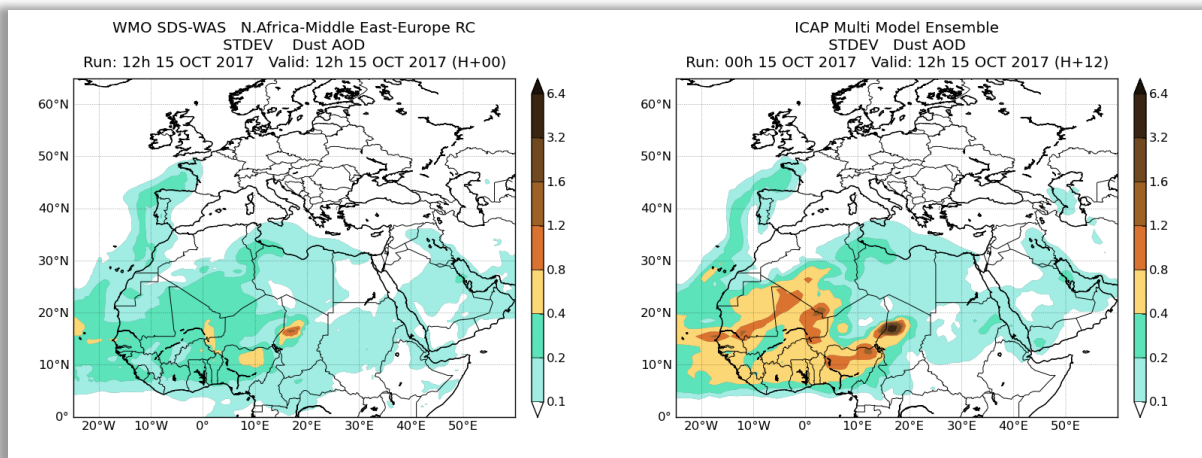
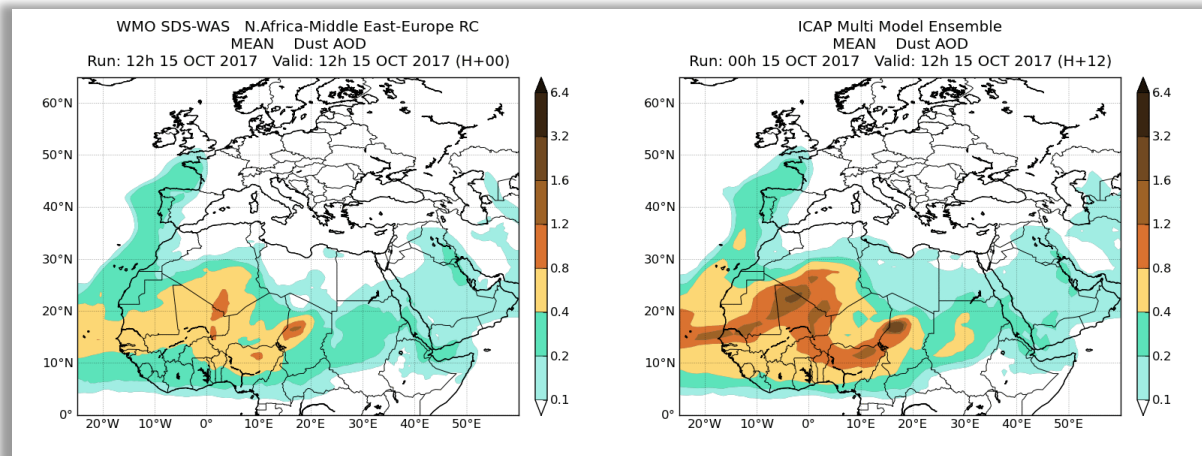
SPREAD: standard deviation – range of variation

SDS-WAS NAMEE: Multi-model - ICAP

Dust AOD at 550nm

from 15-Oct-2017 12:00 to 18-Oct-2017 00:00

Only global models!

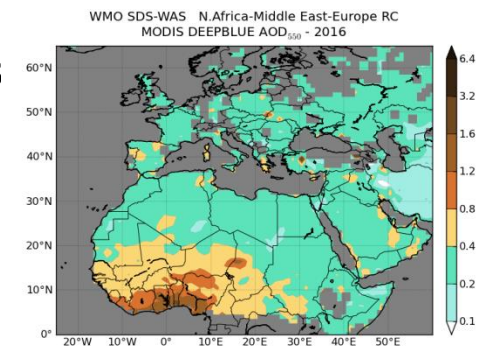
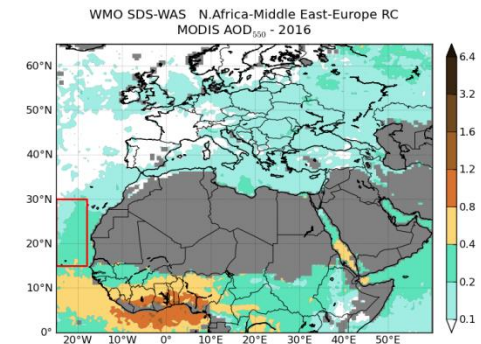


SDS-WAS NAMEE: DOD Model Evaluation

- **Evaluation with AERONET data**
 - Graphical NRT Evaluation by site
 - Evaluation scores monthly/seasonal/annual and sites
- **Evaluation with MODIS data onto the Atlantic**
 - Evaluation scores monthly/seasonal/annual

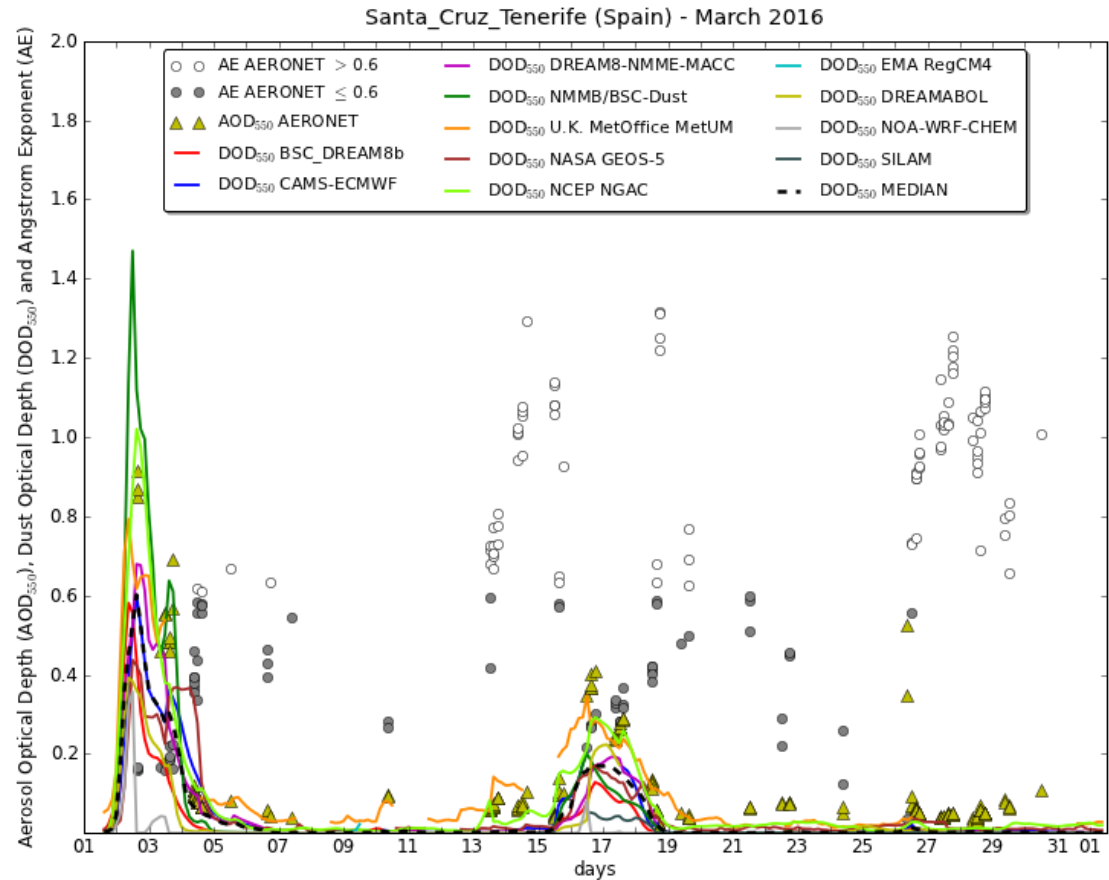


- **Evaluation of dust models with MODIS Deep Blue retrievals**
 - Evaluation scores monthly/seasonal/annual



<http://sds-was.aemet.es/forecast-products/forecast-evaluation>

SDS-WAS NAMEE: DOD AERONET Evaluation



SDS-WAS NAMEE: DOD AERONET Evaluation



A set of evaluation metrics are selected: **Bias**, **RMSE**, **correlation coefficient** and **FGE**

Calculations evaluation metrics are done for:

- **monthly/seasonal/annual**
- **sites and regions**

Date: - Select Year - ▼

Jan 2016 - Dec 2016. Dust Optical Depth.
Threshold Angstrom Exponent = 0.600

BIAS

	BSC_ DREAMb	CAMS- ECMWT	DREAMS- NMME- MACC	NMMB/ BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	SEAM	MEDIAN
Sahel/Sahara show stations	-0.30	-0.17	-0.20	-0.11	-0.16	-0.20	-0.06	0.03	-0.13	-0.13	-0.06	-0.18
Middle East show stations	-0.12	-0.10	-0.05	-0.17	-0.12	-0.16	-0.11	1.13	0.06	-0.14	0.01	-0.13
Mediterranean show stations	-0.16	-0.12	-0.12	-0.15	-0.10	-0.14	-0.05	-0.02	-0.09	-0.12	-0.10	-0.13
TOTAL	-0.24	-0.14	-0.16	-0.13	-0.14	-0.18	-0.06	0.08	-0.10	-0.13	-0.07	-0.16

ROOT MEAN SQUARE ERROR

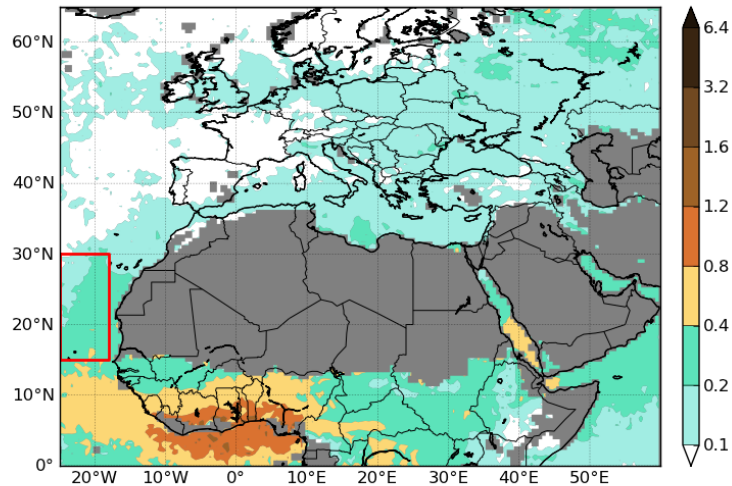
	BSC_ DREAMb	CAMS- ECMWT	DREAMS- NMME- MACC	NMMB/ BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	SEAM	MEDIAN
Sahel/Sahara show stations	0.51	0.42	0.45	0.43	0.44	0.42	0.39	0.64	0.48	0.44	0.82	0.42
Middle East show stations	0.35	0.25	0.28	0.44	0.27	0.31	0.29	11.39	0.34	0.32	0.62	0.28
Mediterranean show stations	0.30	0.29	0.30	0.29	0.27	0.29	0.27	0.40	0.30	0.31	0.44	0.28
TOTAL	0.44	0.37	0.39	0.39	0.38	0.38	0.35	2.86	0.42	0.39	0.71	0.37

CORRELATION COEFFICIENT

	BSC_ DREAMb	CAMS- ECMWT	DREAMS- NMME- MACC	NMMB/ BSC-Dust	U.K. Met Office	NASA GEOS-5	NCEP NGAC	EMA RegCM4	DREAM ABOL	NOA-WRF- CHEM	SEAM	MEDIAN
Sahel/Sahara show stations	0.43	0.53	0.46	0.54	0.48	0.58	0.73	0.17	0.31	0.41	0.18	0.50
Middle East show stations	0.35	0.25	0.28	0.44	0.27	0.31	0.29	11.39	0.34	0.32	0.62	0.28
Mediterranean show stations	0.30	0.29	0.30	0.29	0.27	0.29	0.27	0.40	0.30	0.31	0.44	0.28
TOTAL	0.44	0.37	0.39	0.39	0.38	0.38	0.35	2.86	0.42	0.39	0.71	0.37

SDS-WAS NAMEE: DOD MODIS Evaluation

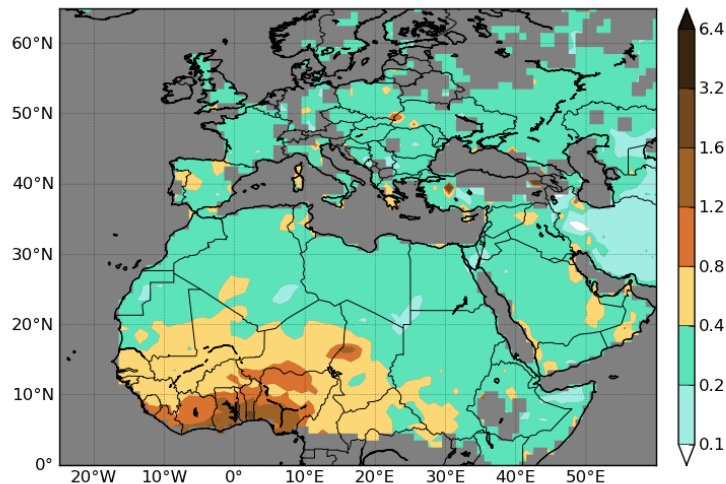
WMO SDS-WAS N.Africa-Middle East-Europe RC
MODIS AOD₅₅₀ - 2016



	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.26	0.70	0.97	18493
NMMB/BSC- Dust	-0.11	0.22	0.72	0.83	18293
NCEP NGAC	0.08	0.21	0.79	0.51	18465
EMA RegCM4	0.03	0.35	0.34	1.11	8039
DREAMABOL	-0.06	0.27	0.51	0.84	17834
NOA-WRF- CHEM	-0.00	0.18	0.79	0.71	18141
SILAM	0.03	0.48	0.45	0.93	12302



WMO SDS-WAS N.Africa-Middle East-Europe RC
MODIS DEEPLUE AOD₅₅₀ - 2016



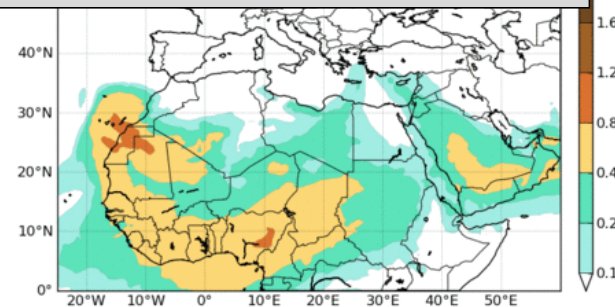
	BIAS	ROOT MEAN SQUARE ERROR	CORRELATION COEFFICIENT	FRACTIONAL GROSS ERROR	NUMBER OF CASES
BSC_ DREAM8b	-0.16	0.32	0.40	0.76	189314
NMMB/BSC- Dust	-0.10	0.29	0.66	0.82	188183
NCEP NGAC	-0.03	0.27	0.52	0.55	189348
EMA RegCM4	0.25	1.51	0.07	0.82	94099
DREAMABOL	-0.01	0.36	0.24	0.70	181446
NOA-WRF- CHEM	-0.04	0.25	0.61	0.59	186946
SILAM	0.10	0.79	0.27	0.93	142429

SDS-WAS NAMEE: Model Evaluation



7 March 2015

New observational datasets for model evaluation in Northern Africa and Middle East

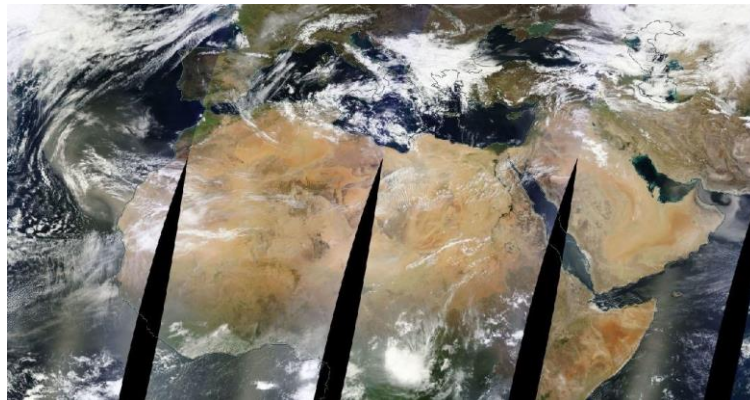


NOTE: There is available an historical archive of the MSG RGB dust products.

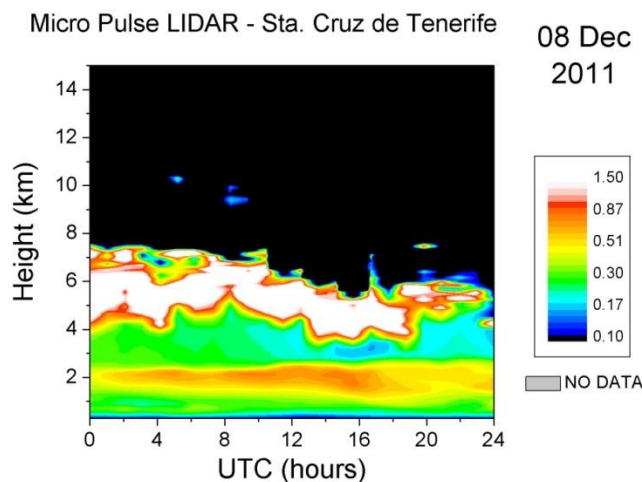
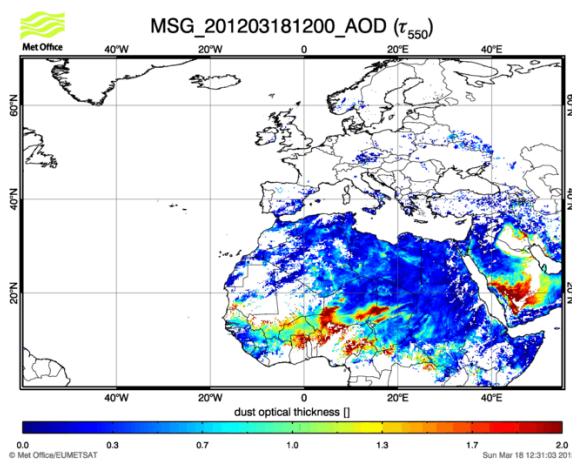
SDS-WAS NAMEE: Model Evaluation

New observational datasets for model evaluation in Northern Africa and Middle East

- Visibility
- MSG/SEVIRI
- MODIS
- OMI
- CALIPSO
- PARASOL
- MPLNET
- PM₁₀

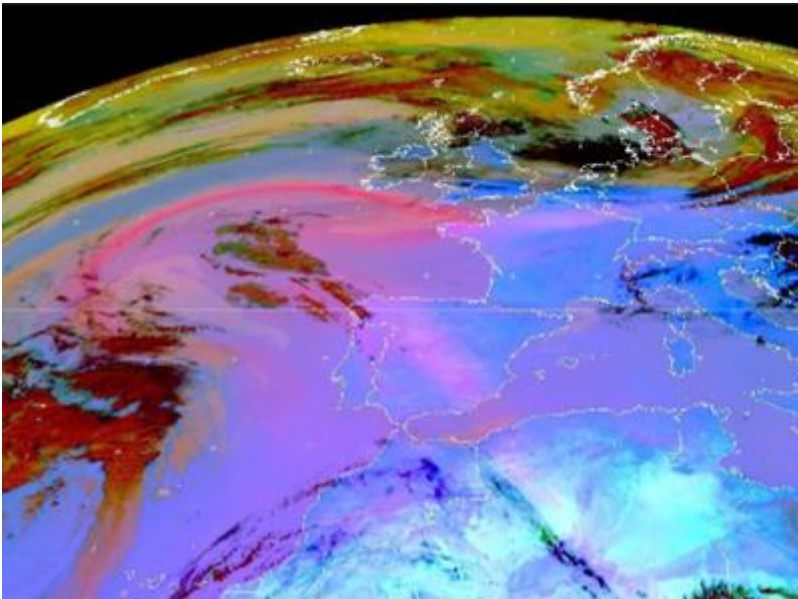


MODIS composite 8th March 2015 from EOSDIS World Viewer



SDS-WAS NAMEE: Studies

Model Intercomparison: European dust outbreak on April 2011



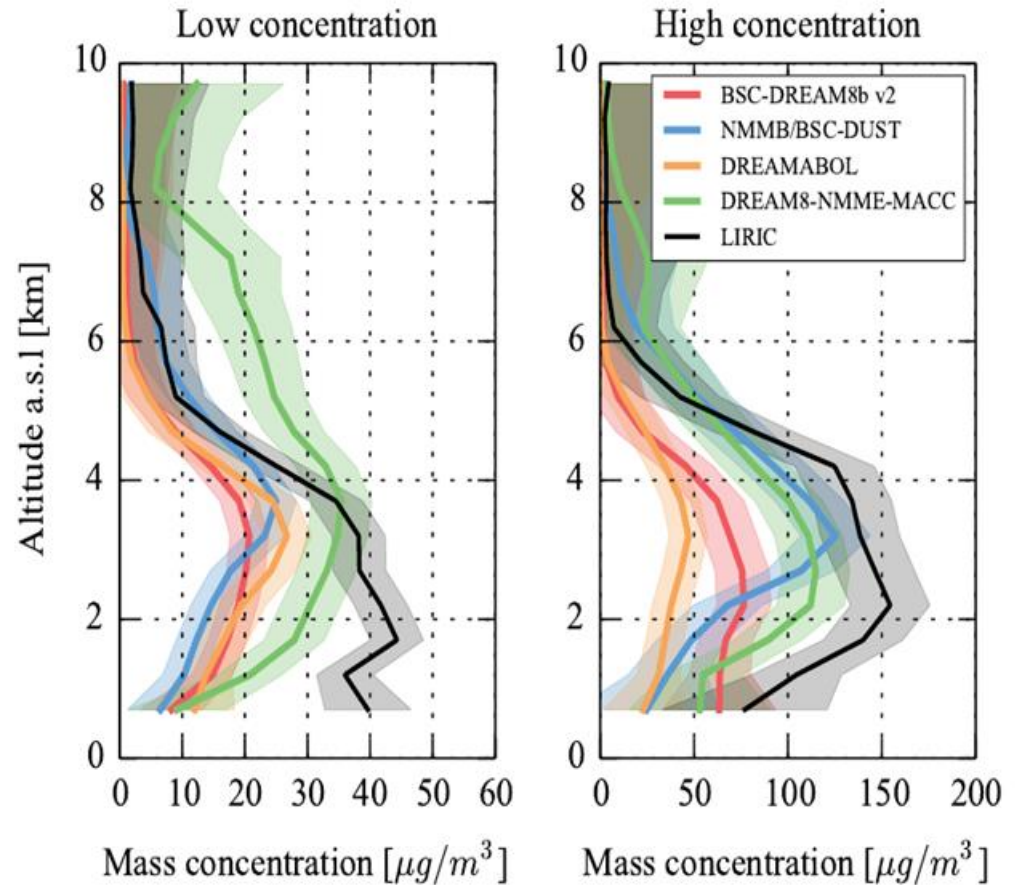
*MSG/SEVIRI RGB product 7 April
Courtesy of EUMETSAT*

- The selected dust event corresponds to the one which occurred between the 5th and 11th of April of 2011.
- Participating models: BSC-DREAM8b, NMMB/BSC-Dust, ECMWF-MACC, UKMetOffice-UM and NMME-DREAM-MACC
- Comparison of each forecast (at 24, 48 and 72h) output to in-situ measurements of AOD (from AERONET), surface concentration (PM) and satellite retrieved AOD (MODIS, CALIPSO) and meteorology.

(Huneus et al., ACP, 2016)

SDS-WAS NAMEE: Studies

Model Intercomparison: EU-EARLINET vertical dust profiles: 2011-2013



(Biniotoglou et al., ATM, 2015)

SDS-WAS NAMEE: Studies

The extreme dust storm occurred in Tehran (Iran) on **2nd June 2014** lasting less than 2 hours according to public evidence.

Based on public news, the dust storm caused several deaths, reduction of visibility to several tenths meters in the city, and adverse disturbance of the public traffic. The blowing wind reached 110 km/h.

This project aims to **better understand generation and development of small-scale dust storms** contributing so to exploring a potential of dust models to more accurately simulate such events, considering them as the most difficult ones to be operationally predicted.



SDS-WAS NAMEE: PM10 Evaluation



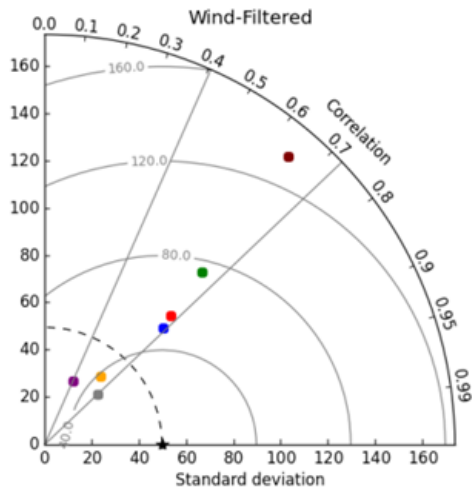
AMMA network: PM10 in Sahel for the year 2013



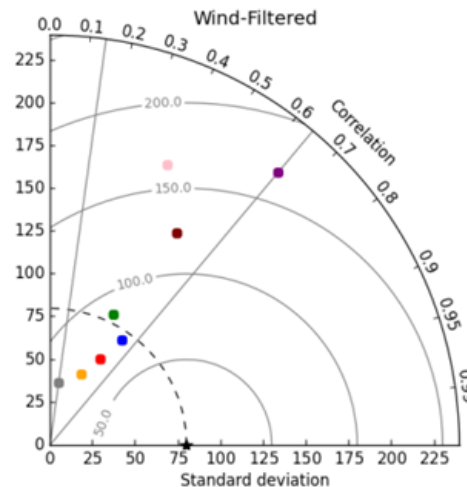
Not all PM10 is dust: Local and biomass burning from Savannah fires.

Dust filter: Considering the localizations of the desert dust sources the filter is based on wind direction.

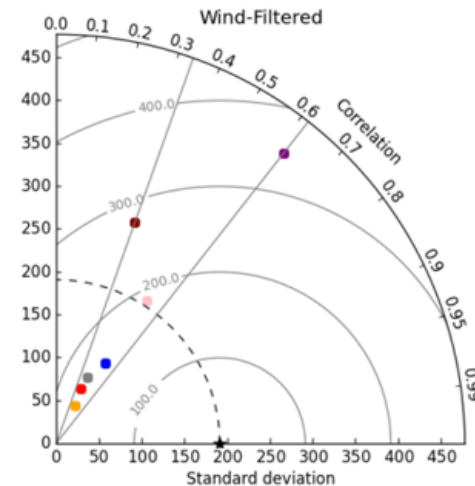
M'Bour-Senegal



Cinzana-Mali



Banizoumbou-Niger



- ★ Reference
- CAMS
- Median
- NGAC
- NMMB/BSC-Dust
- BSC-DREAM8b
- GEOS-5
- MetUM
- DREAM8-NMME

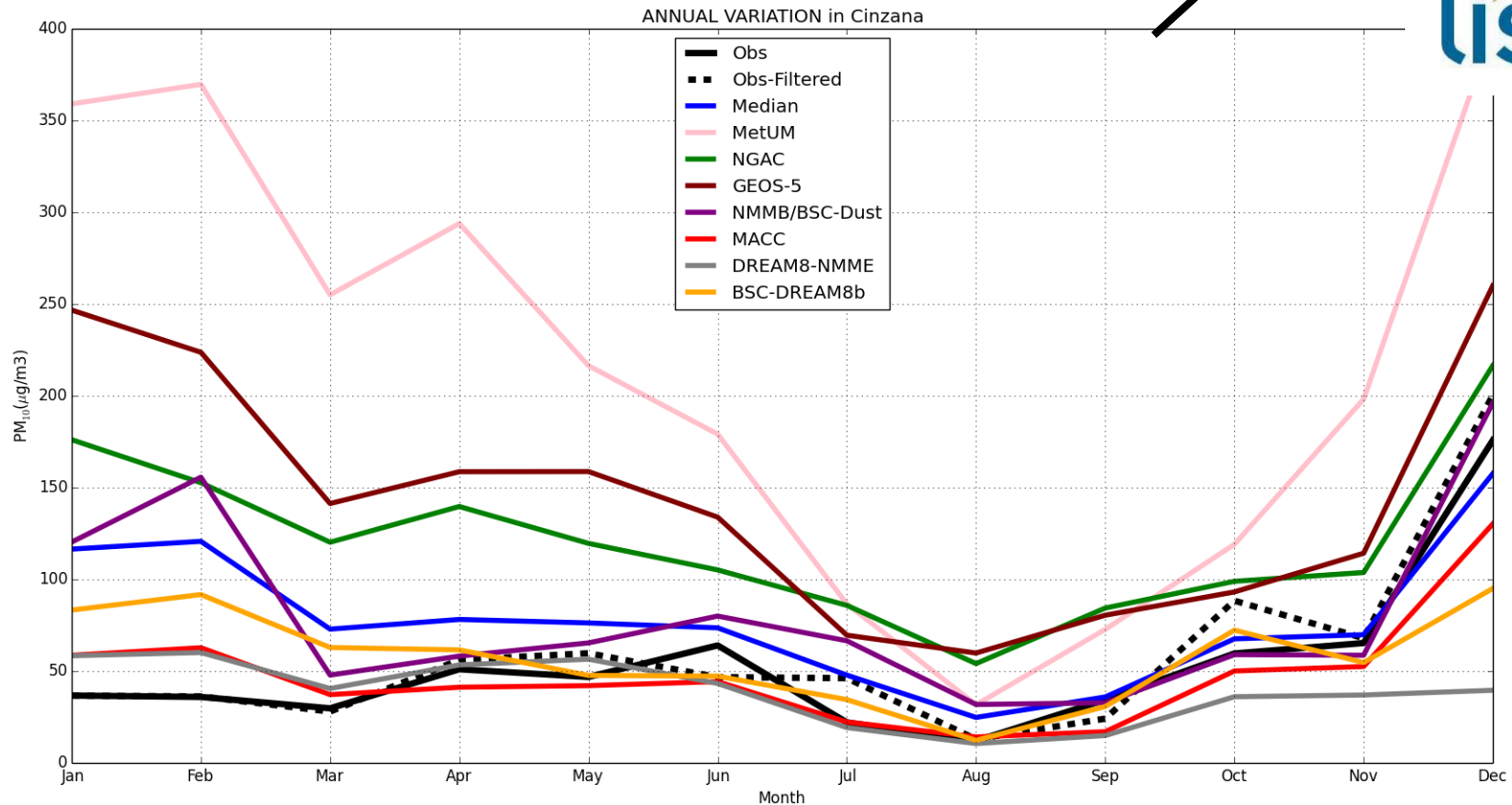
AMMA (Marticorena et al., 2010)

SDS-WAS NAMEE: PM10 Evaluation

AMMA network: PM10 in Sahel for the year 2013



lisa

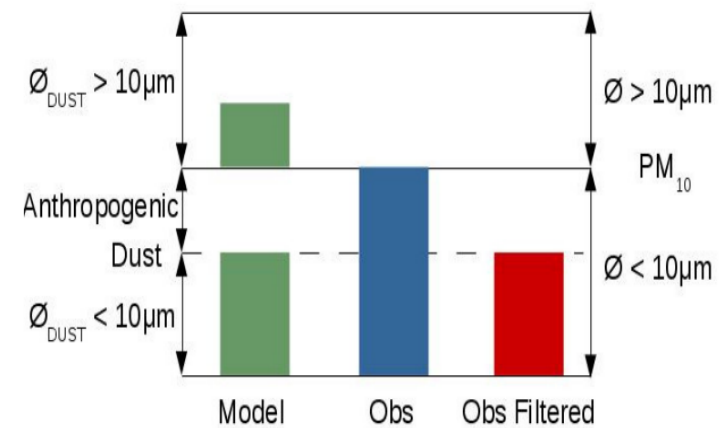


SDS-WAS NAMEE: PM10 Evaluation

AQ network: Canary Islands 2013-2014

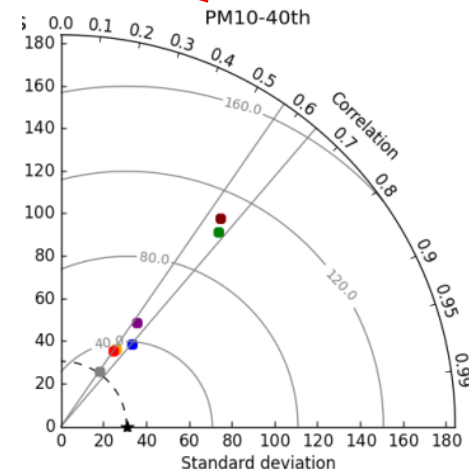
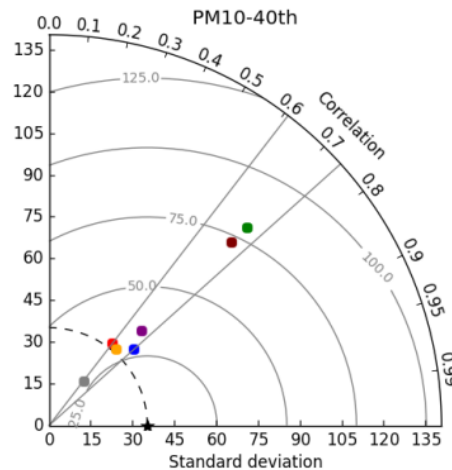
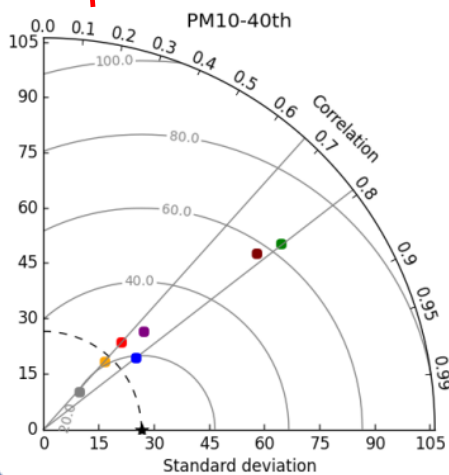
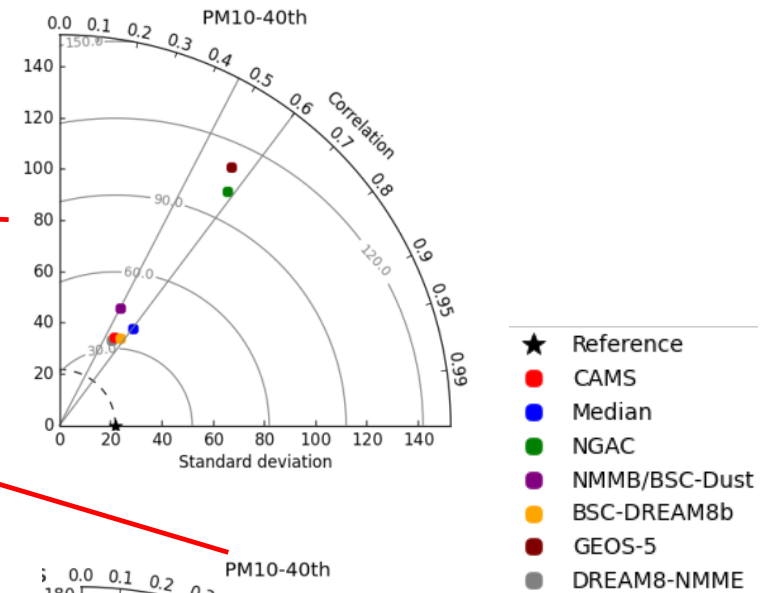


Not all PM10 is dust: Local sources
Dust filter: Moving 40th percentile of 30 days,
15 days before and 15 days after (Escudero et al. 2007).



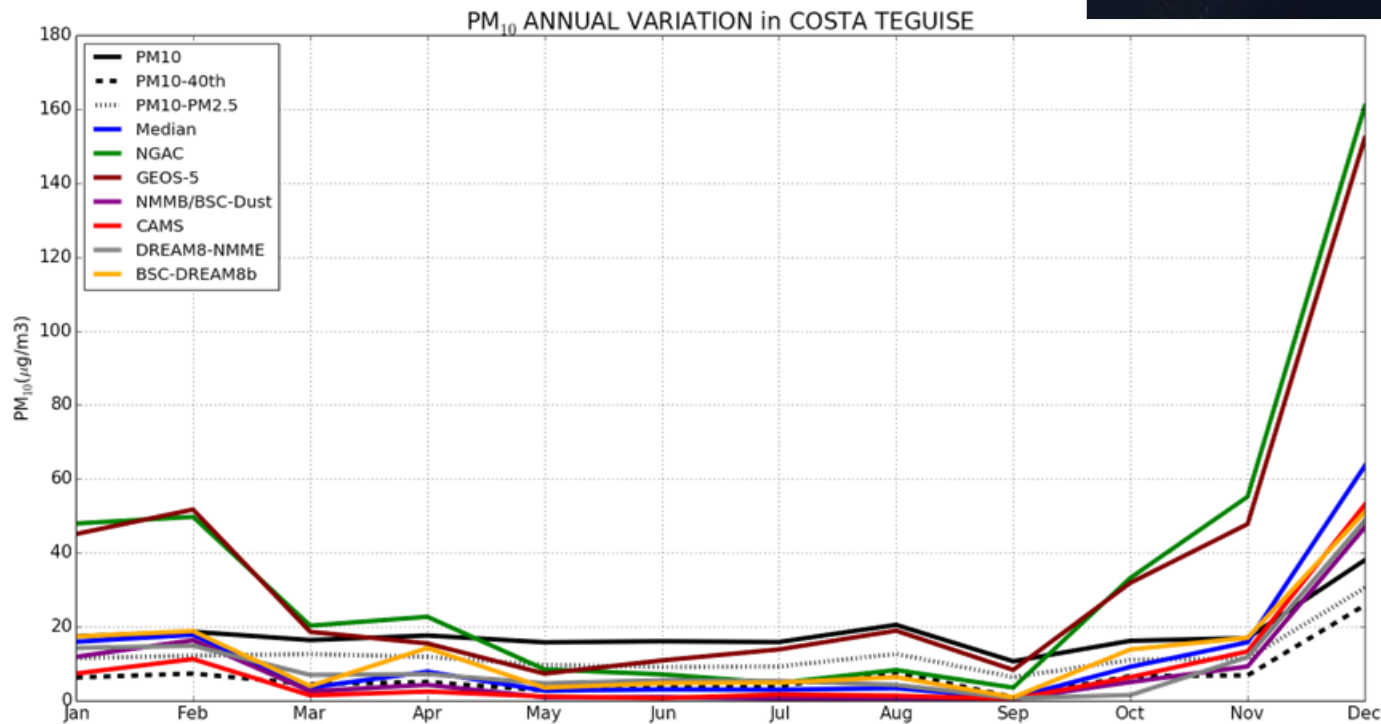
SDS-WAS NAMEE: PM10 Evaluation

AQ network: Canary Islands 2013-2014



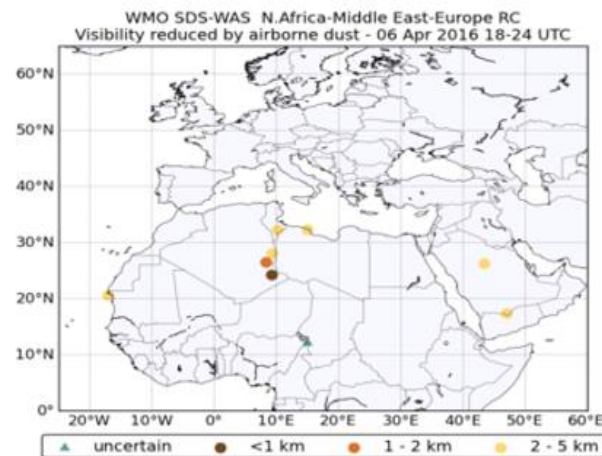
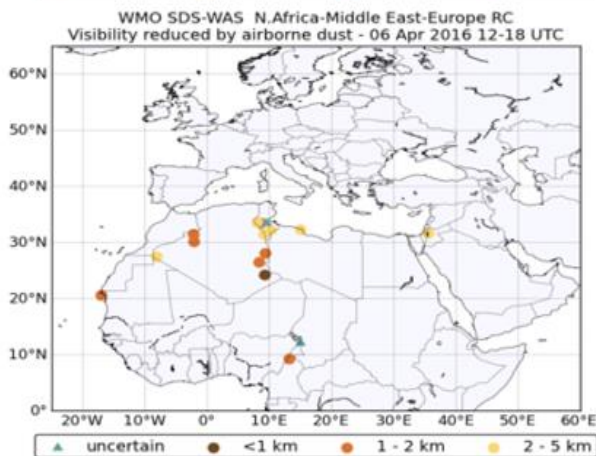
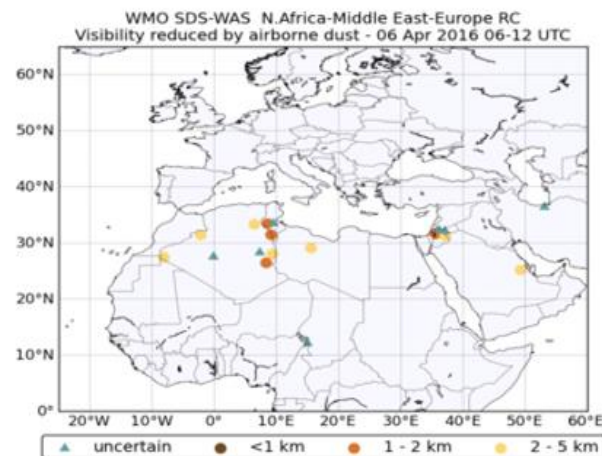
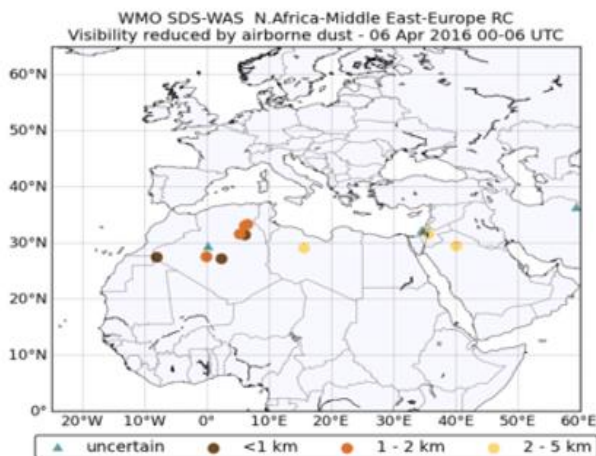
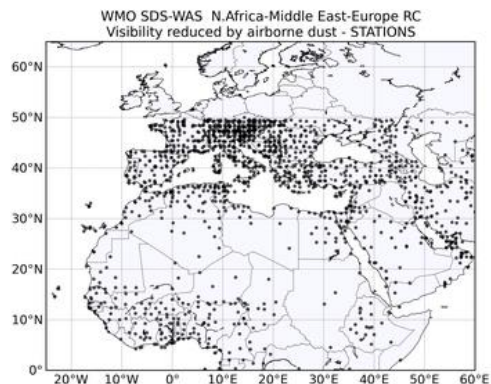
SDS-WAS NAMEE: PM10 Evaluation

AQ network: Canary Islands 2013-2014



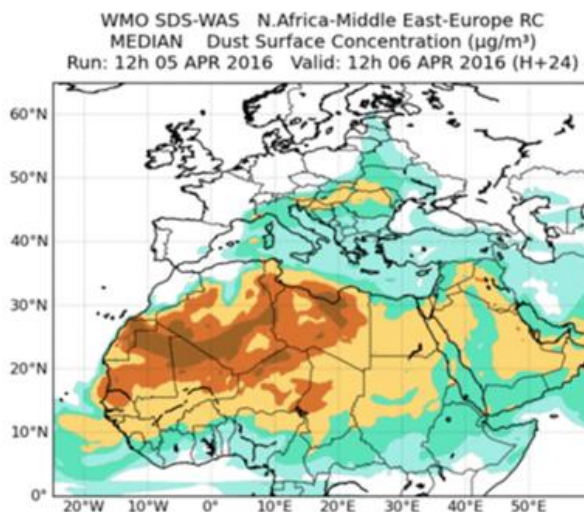
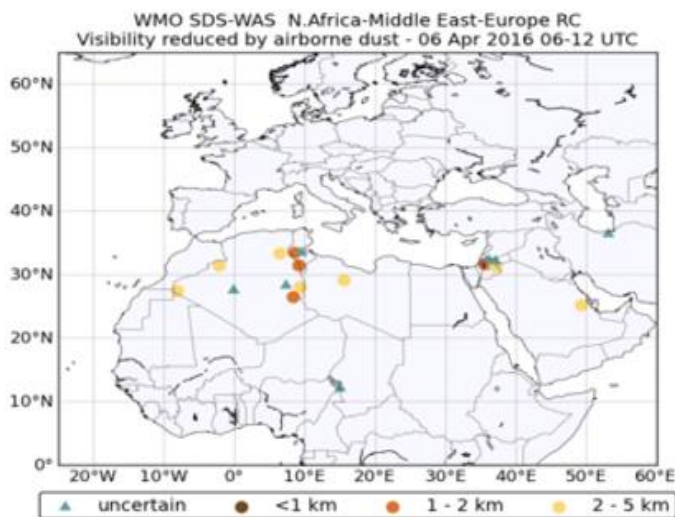
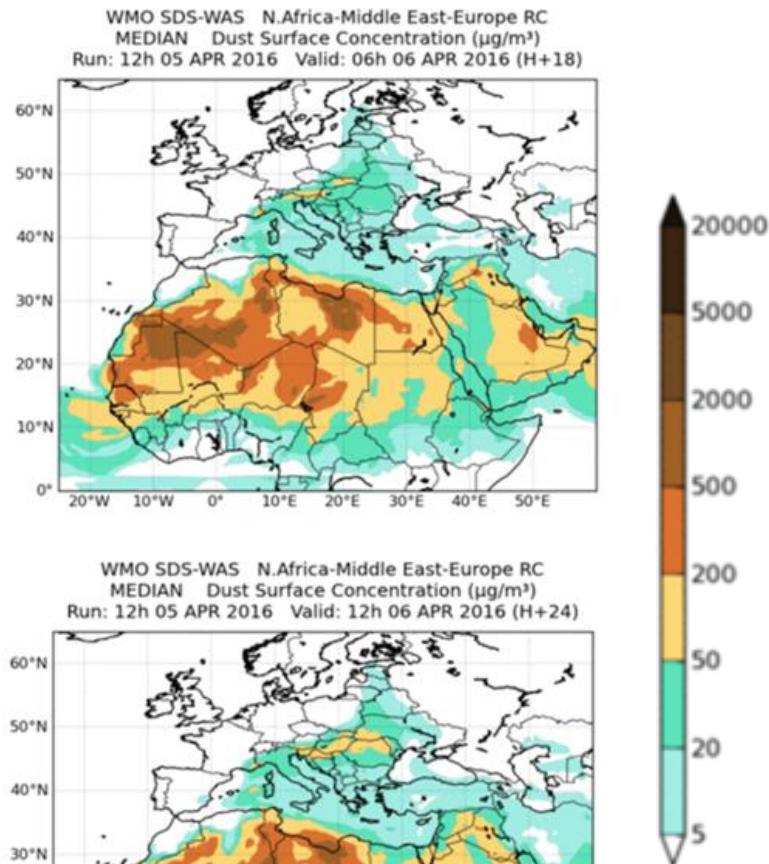
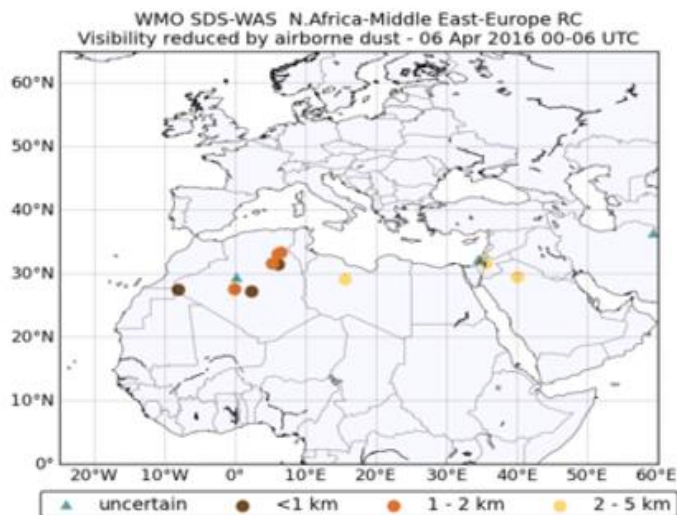
SDS-WAS NAMEE: Visibility vs Surf. Conc.

NRT visibility evaluation: 6th April 2016 0-12UTC



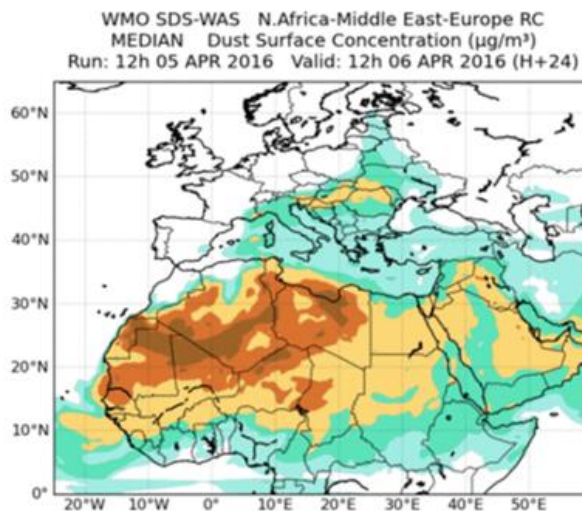
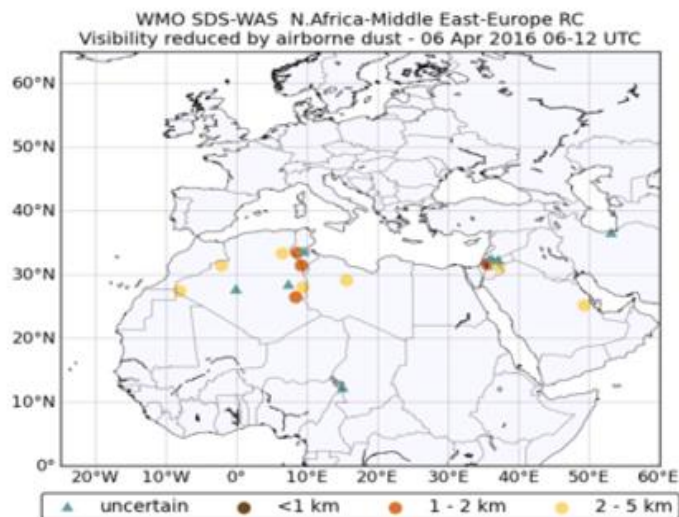
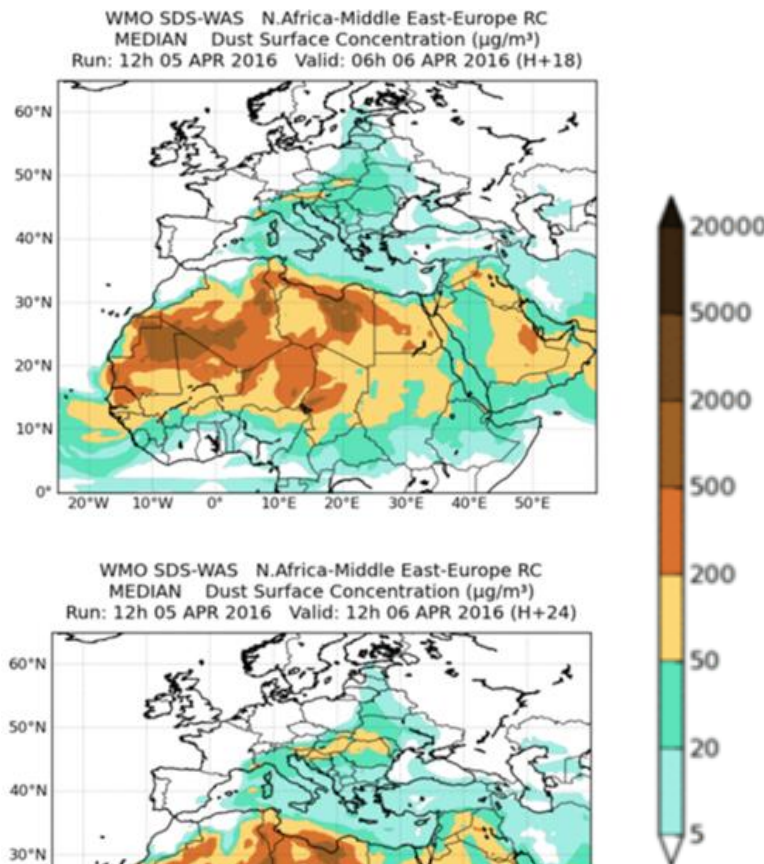
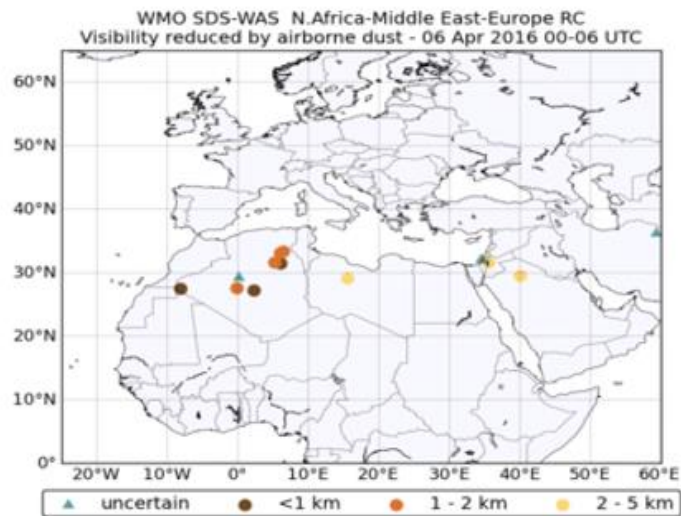
SDS-WAS NAMEE: Visibility vs Surf. Conc.

NRT visibility evaluation: 6th April 2016 0-12UTC



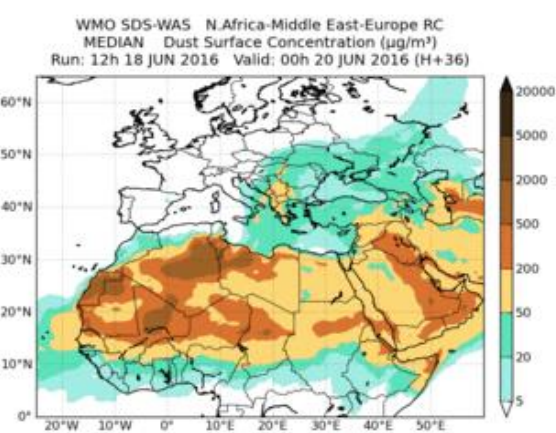
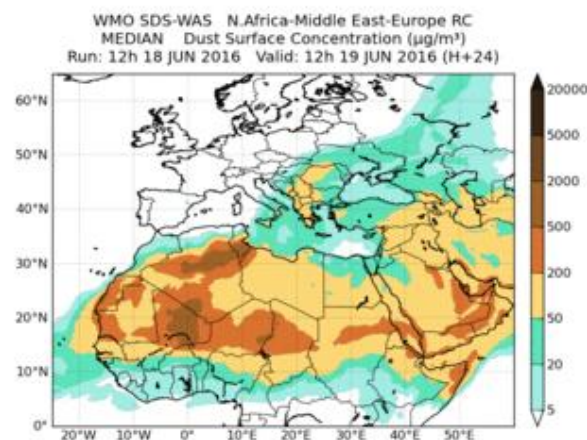
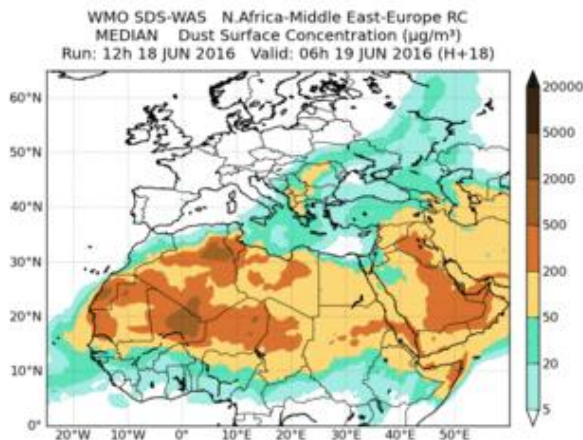
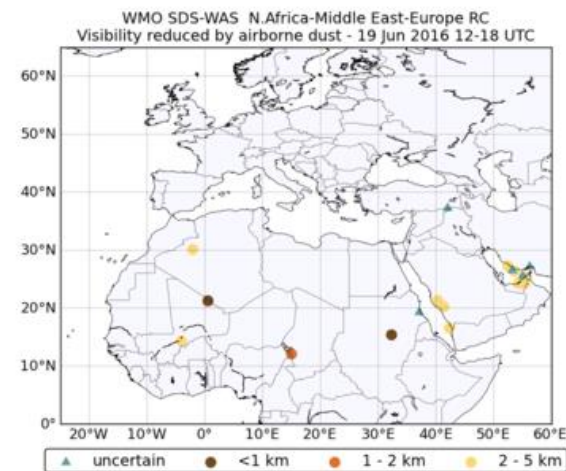
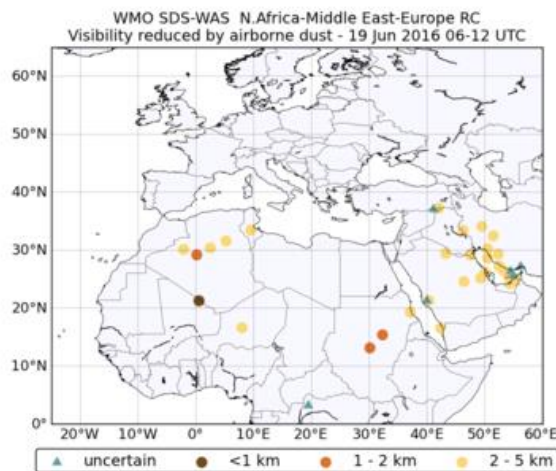
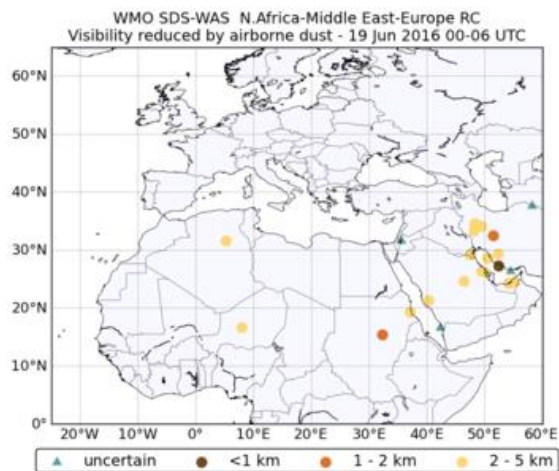
SDS-WAS NAMEE: Visibility vs Surf. Conc.

NRT visibility evaluation: 6th April 2016 0-12UTC



SDS-WAS NAMEE: Visibility vs Surf. Conc.

NRT visibility evaluation: 19th june 2016



SDS-WAS NAMEE: Dust Profiles Evaluation

Ceilometers

Tenerife, Granada and Montsec (Spain)

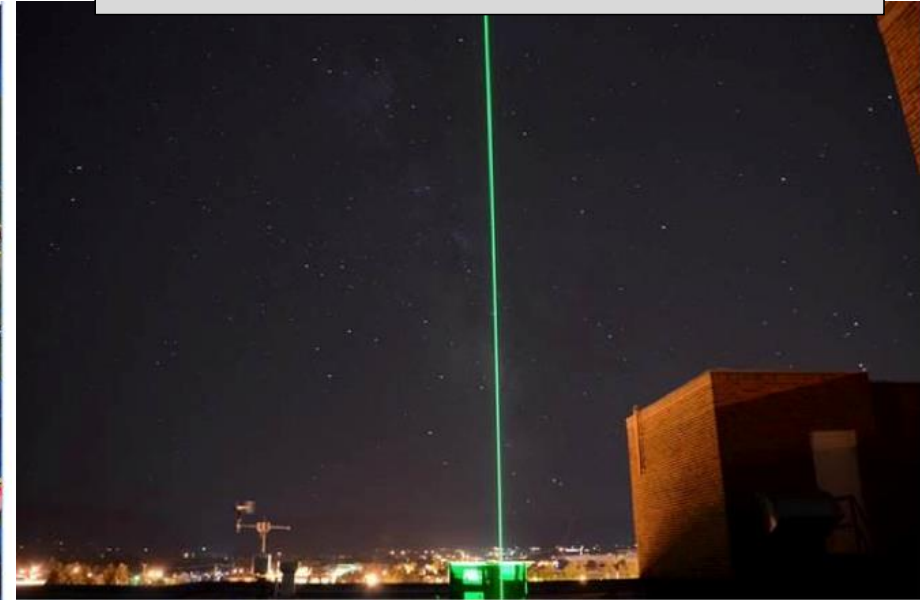
- + High density of stations
- Qualitative products



Lidar

M'Bour (Senegal)

- Low number of stations
- + Quantitative products



ugr

idæa



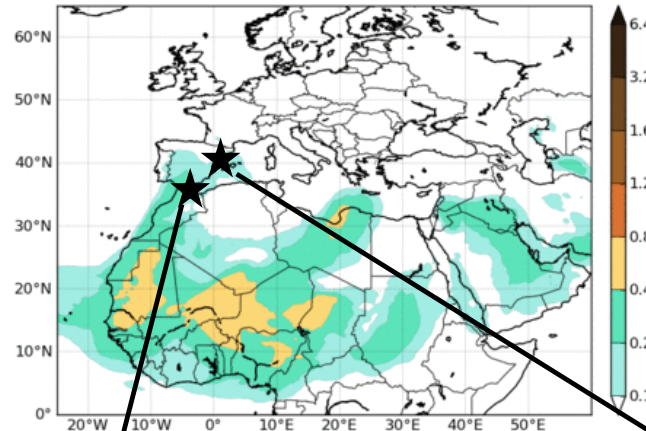
<http://sds-was.aemet.es/projects-research/evaluation-of-model-derived-dust-vertical-profiles>



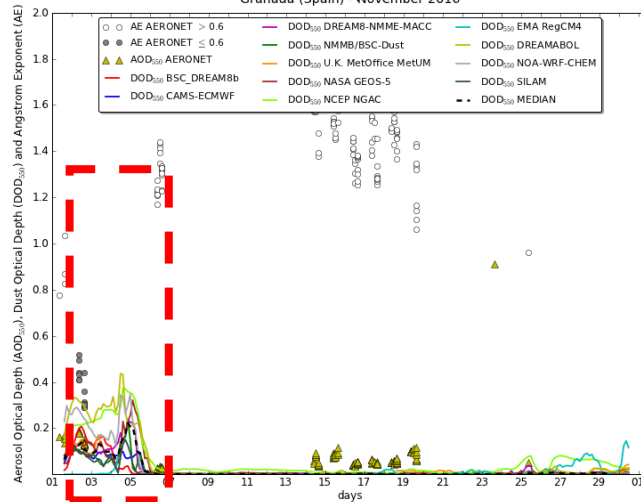
SDS-WAS NAMEE: Dust Profiles Evaluation

W. Mediterranean dust event: 2 - 5 November 2016

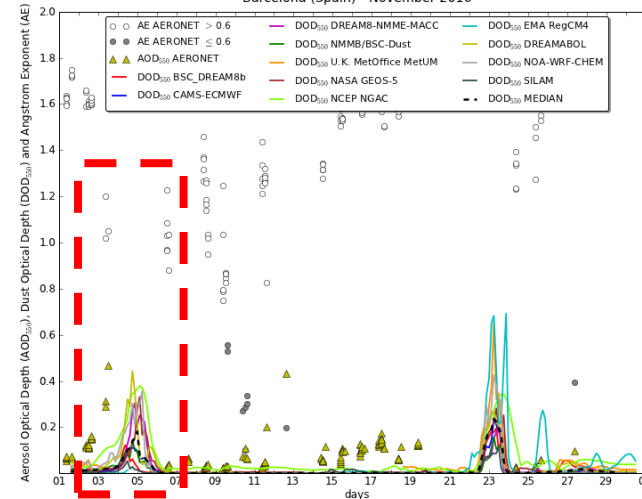
WMO SDS-WAS N.Africa-Middle East-Europe RC
MEDIAN Dust AOD
Run: 12h 04 NOV 2016 Valid: 12h 04 NOV 2016 (H+00)



Granada (Spain) - November 2016



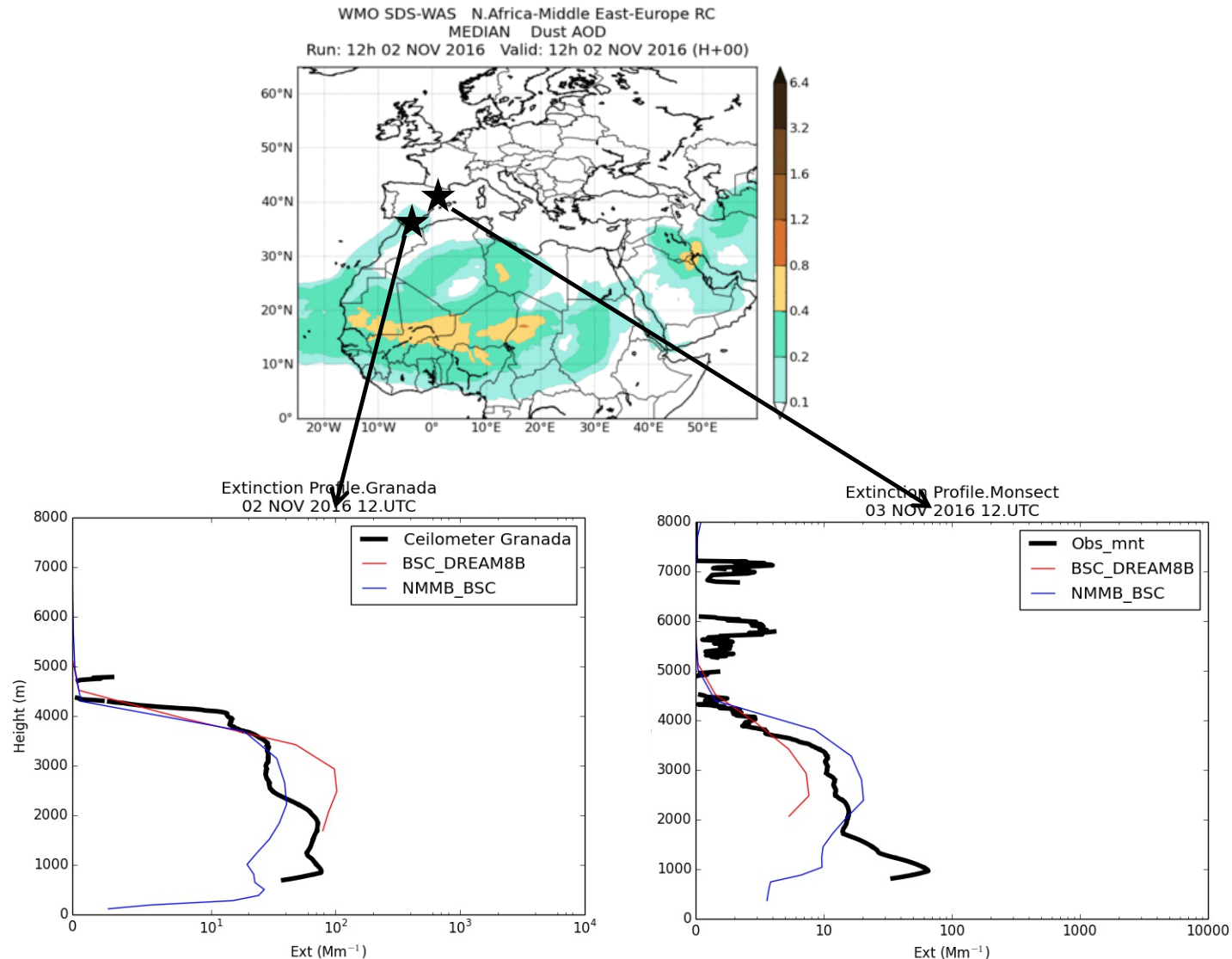
Barcelona (Spain) - November 2016



AERONET

SDS-WAS NAMEE: Dust Profiles Evaluation

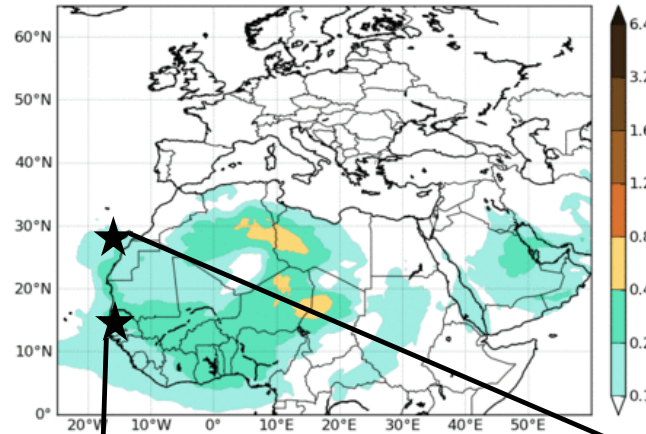
Atlantic dust event: 2 - 5 November 2016



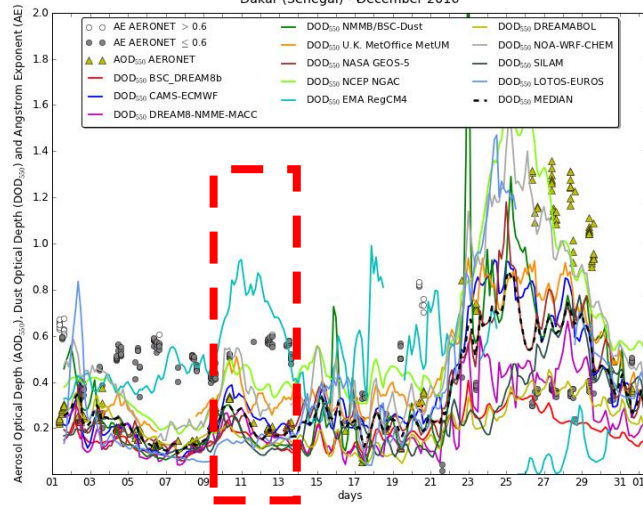
SDS-WAS NAMEE: Dust Profiles Evaluation

Atlantic dust event: 9 - 12 December 2016

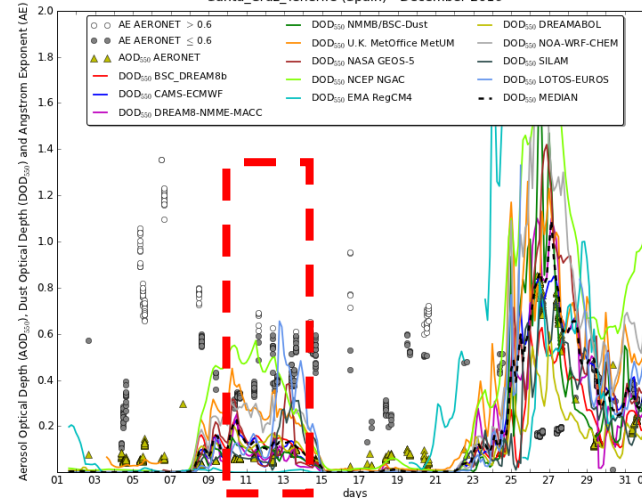
WMO SDS-WAS N.Africa-Middle East-Europe RC
MEDIAN Dust AOD
Run: 12h 09 DEC 2016 Valid: 12h 09 DEC 2016 (H+00)



Dakar (Senegal) - December 2016



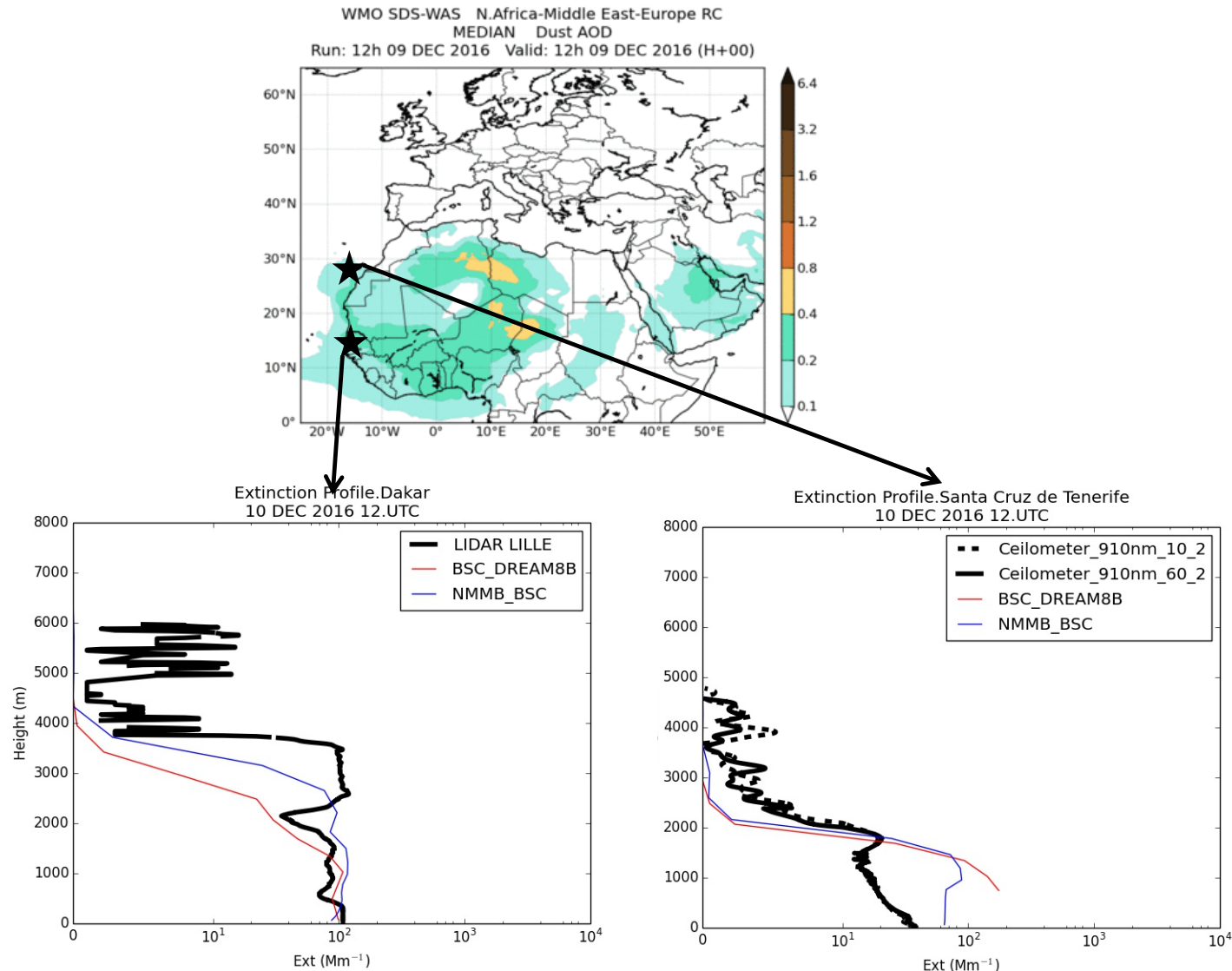
Santa_Cruz_Tenerife (Spain) - December 2016



AERONET

SDS-WAS NAMEE: Dust Profiles Evaluation

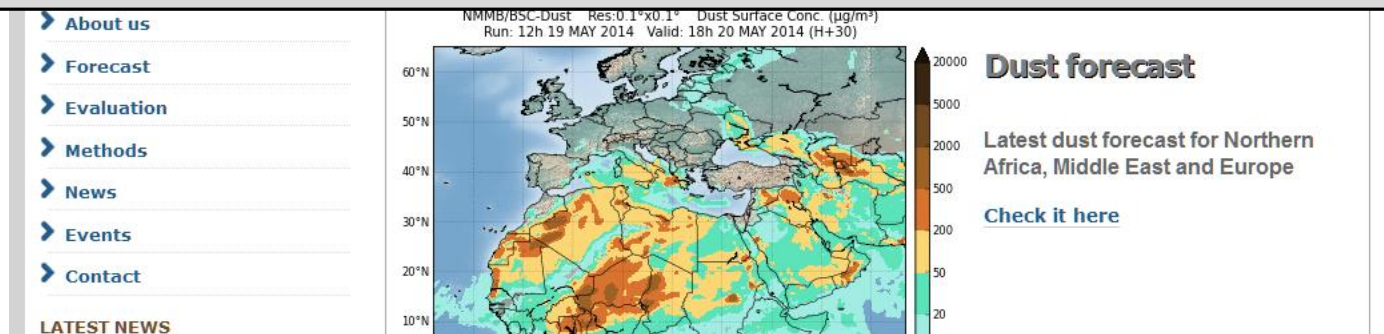
Atlantic dust event: 9 - 12 December 2016



Barcelona Dust Forecasting Center



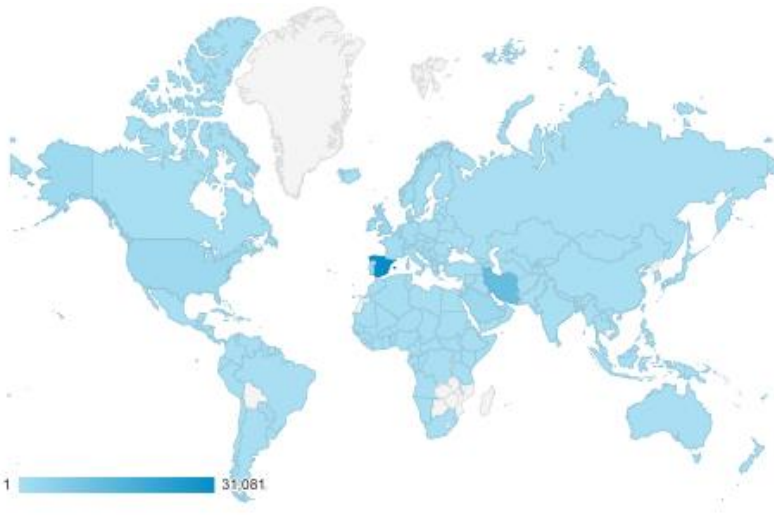
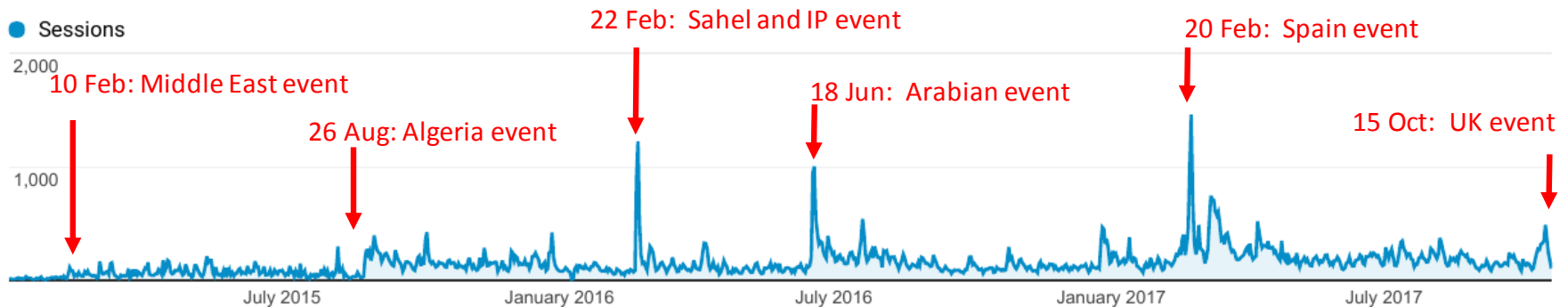
In 2014, the First Specialized Center for Mineral Dust Prediction of WMO is created
NMMB/BSC-Dust selected to provide operational forecasts for NAMEE region



Barcelona Dust Forecasting Center

Website visits: 1 January 2015 – 20 October 2017

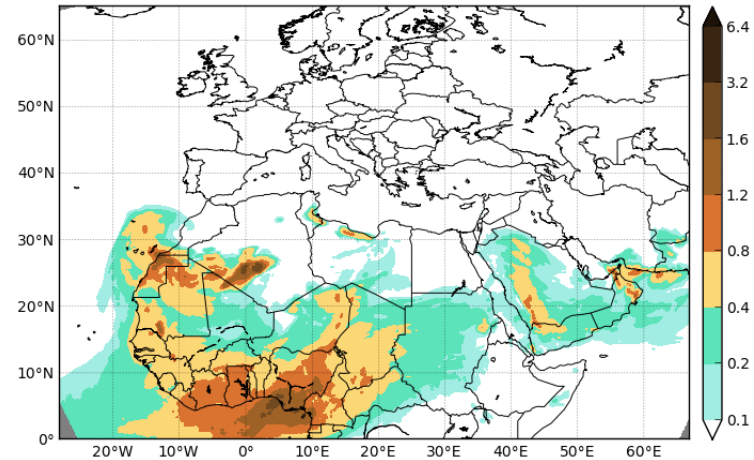
<http://dust.aemet.es/>



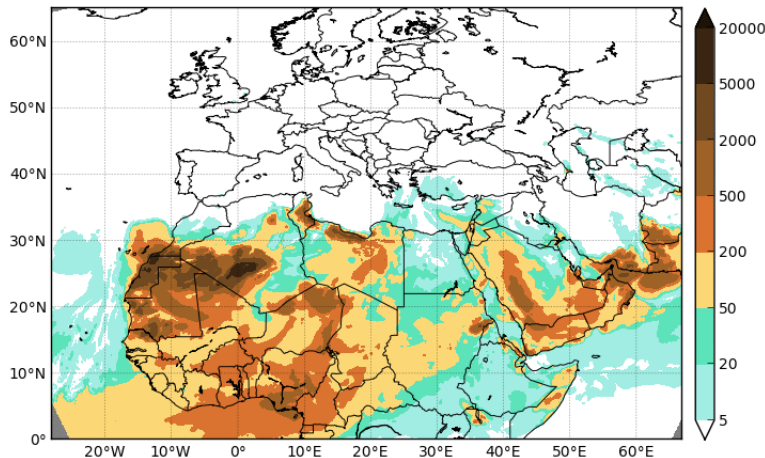
BDFC: Operational Products

Dust Optical Depth at 550nm
Dust Dry Deposition
Dust Load
Dust Surface Concentration
Dust Surface Extinction at 550nm
Dust Wet Deposition

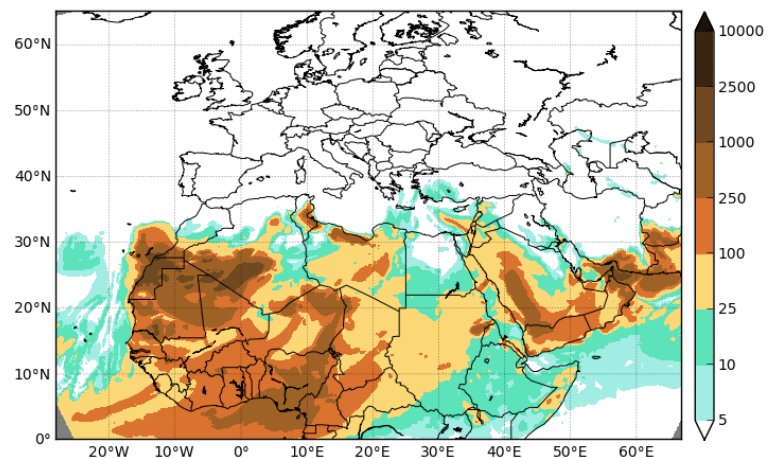
Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)



Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Conc. ($\mu\text{g}/\text{m}^3$)
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)

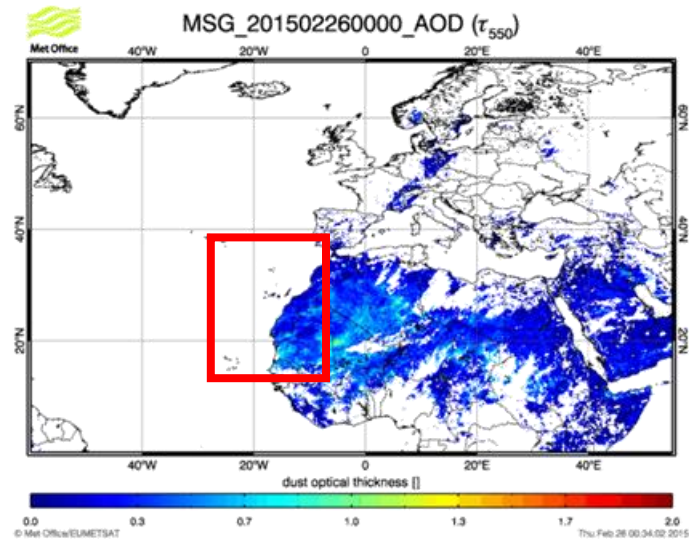
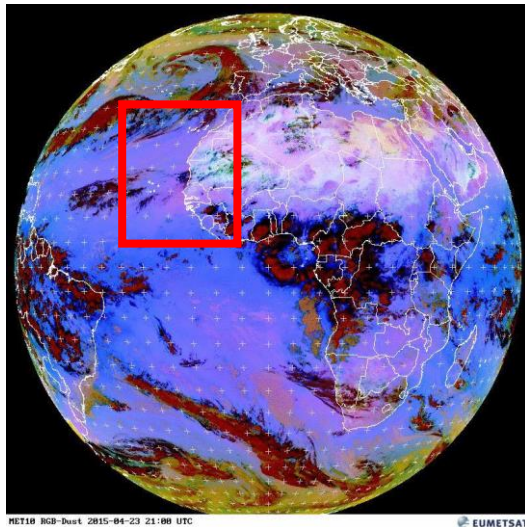
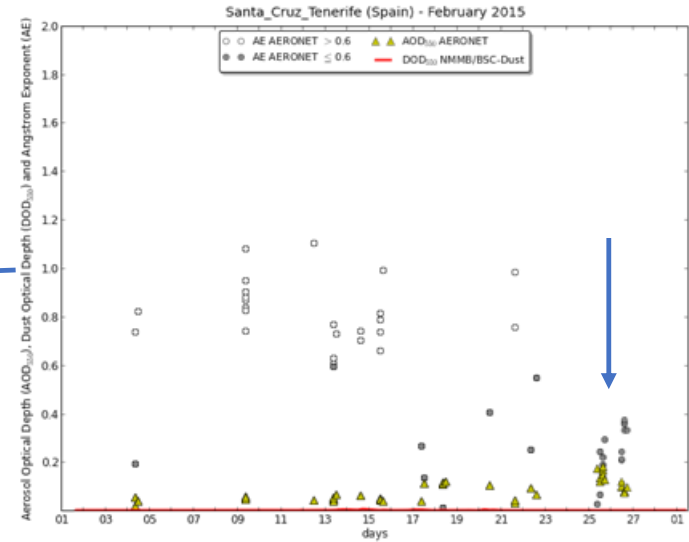
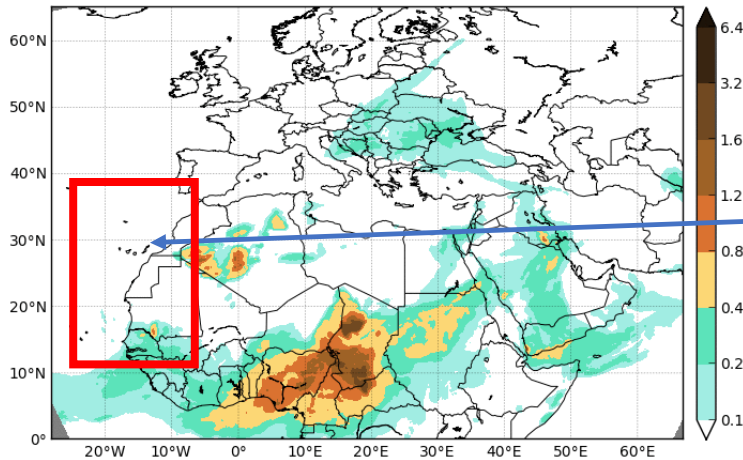


Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust Surface Ext. (Mm^{-1})
Run: 12h 07 MAR 2015 Valid: 12h 07 MAR 2015 (H+00)



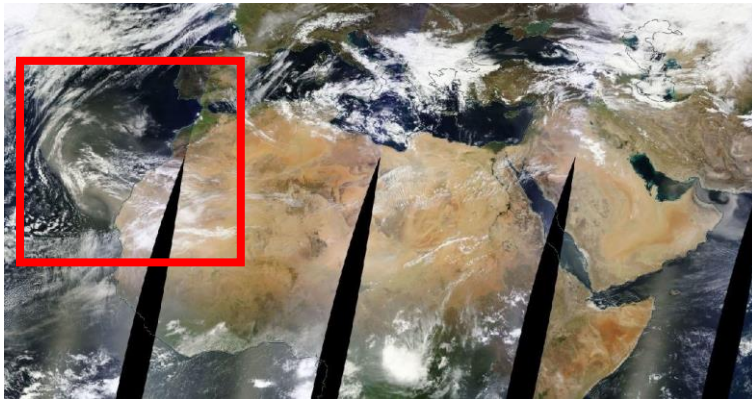
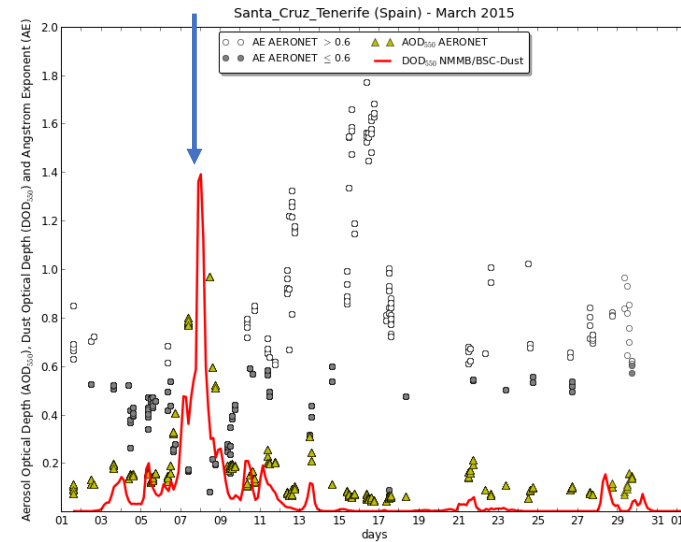
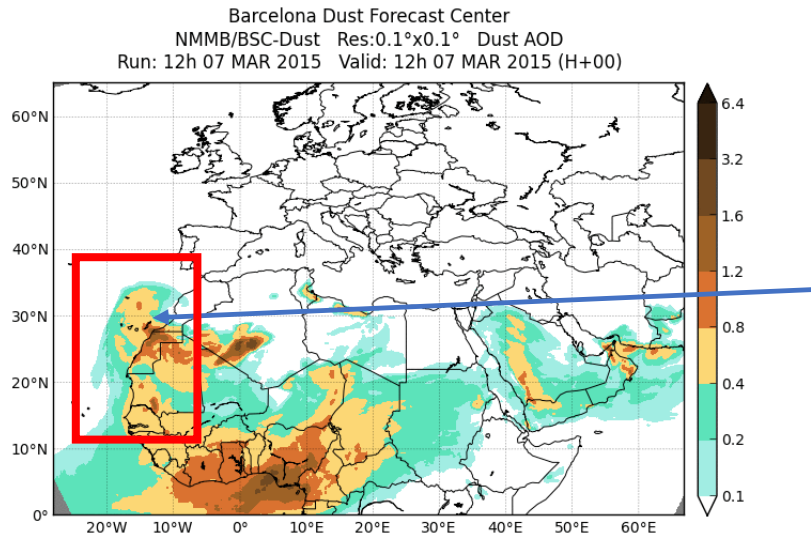
BDFC: Dust event Canary Islands Feb 2015

Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 25 FEB 2015 Valid: 12h 25 FEB 2015 (H+00)

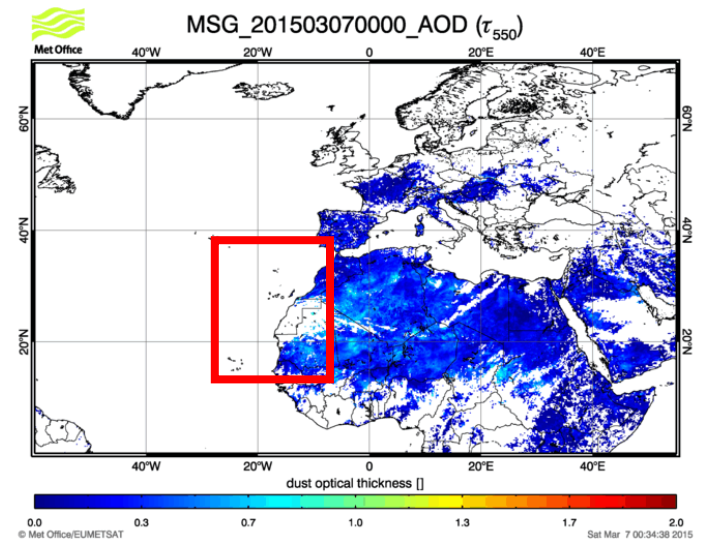


<http://dust.aemet.es/>

BDFC: Dust event Canary Islands Mar 2015



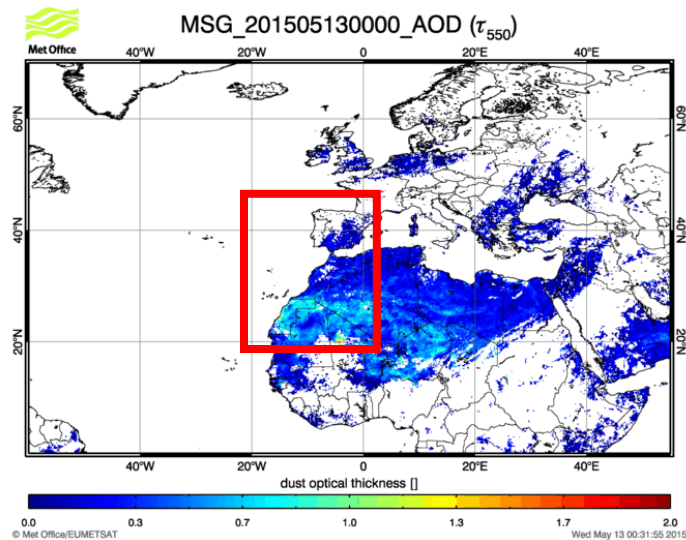
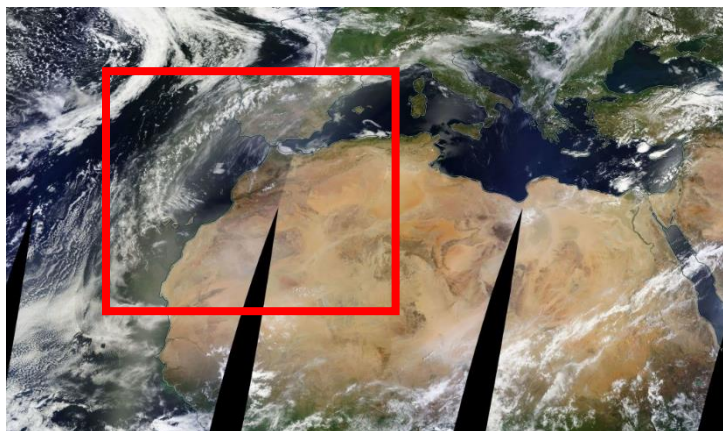
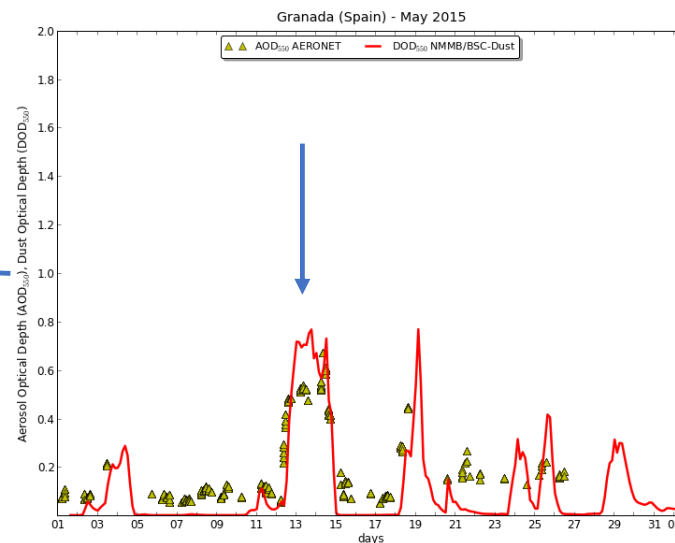
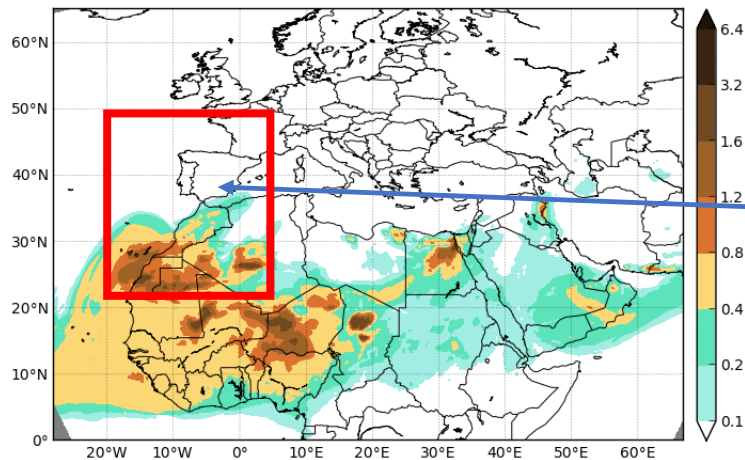
MODIS composite 8th March 2015
from EOSDIS World Viewer



<http://dust.aemet.es/>

BDFC: Dust event Europe May 2015

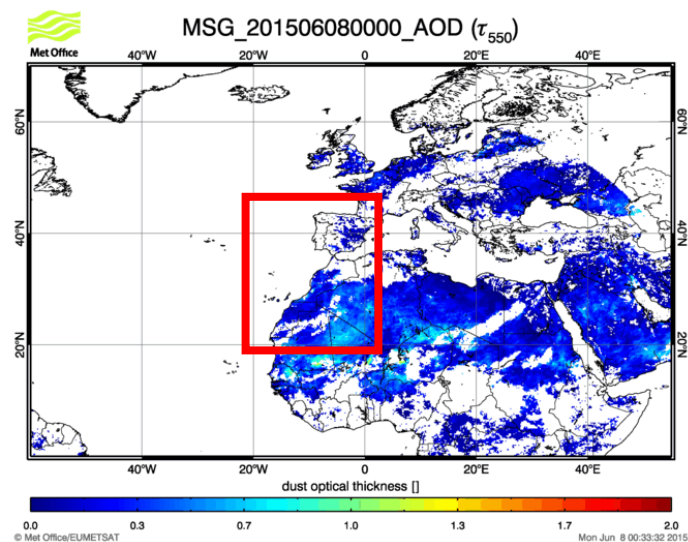
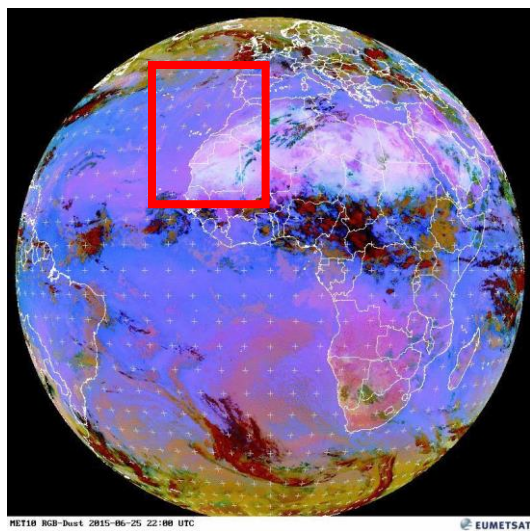
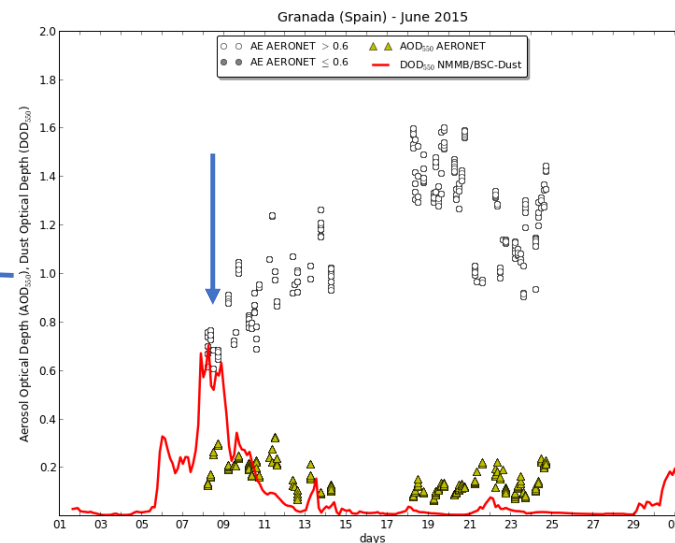
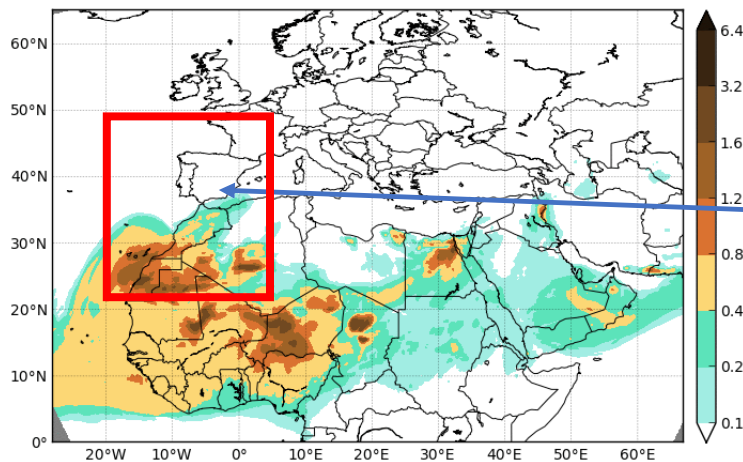
Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 11 MAY 2015 Valid: 12h 11 MAY 2015 (H+00)



<http://dust.aemet.es/>

BDFC: Dust event Europe June 2015

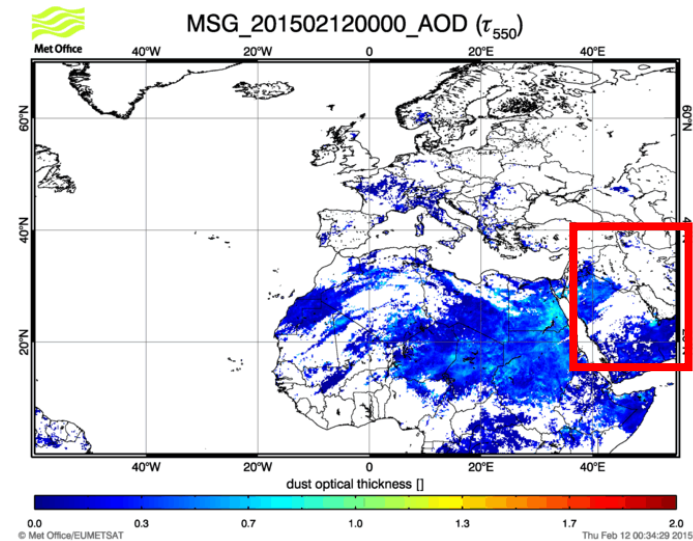
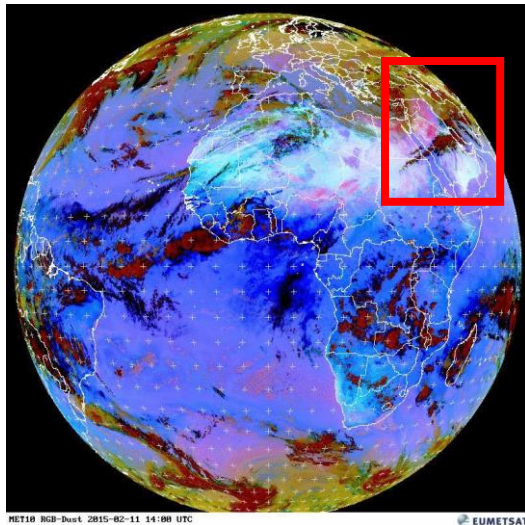
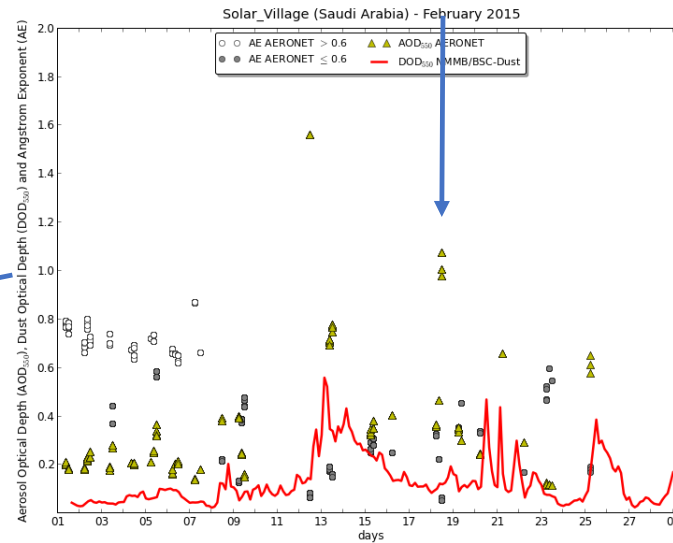
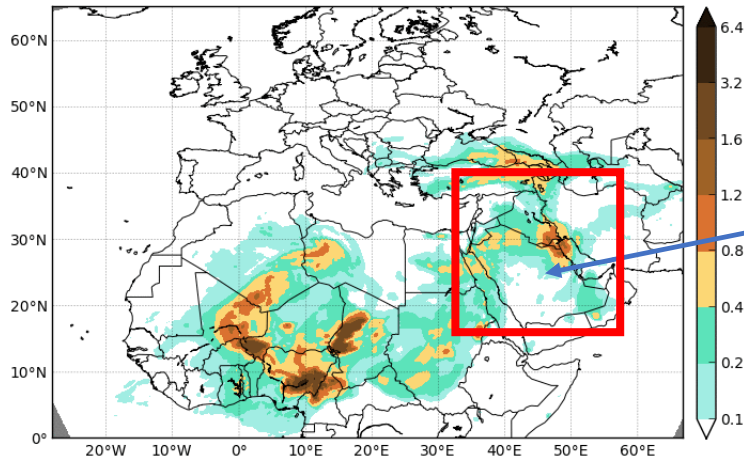
Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 11 MAY 2015 Valid: 12h 11 MAY 2015 (H+00)



<http://dust.aemet.es/>

BDFC: Dust event Middle East Feb 2015

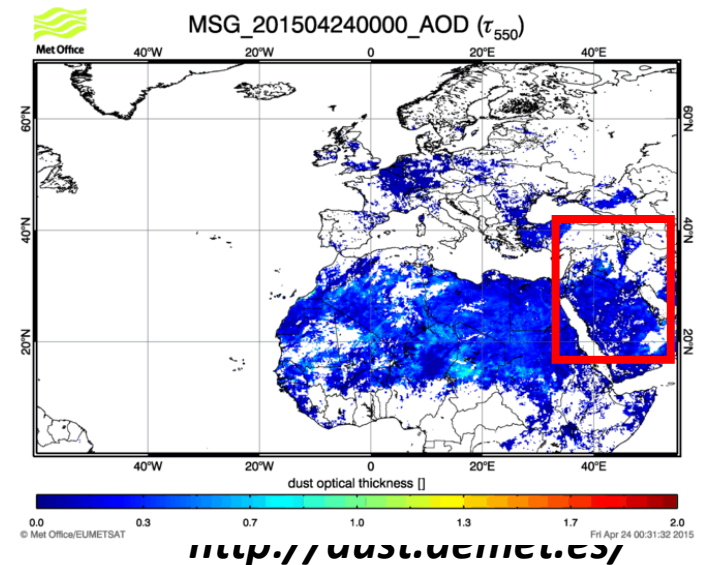
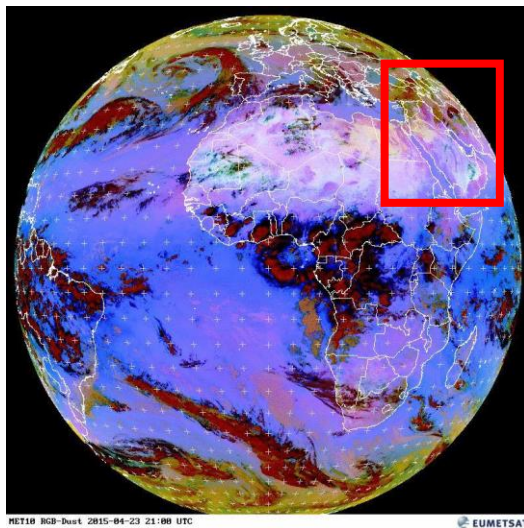
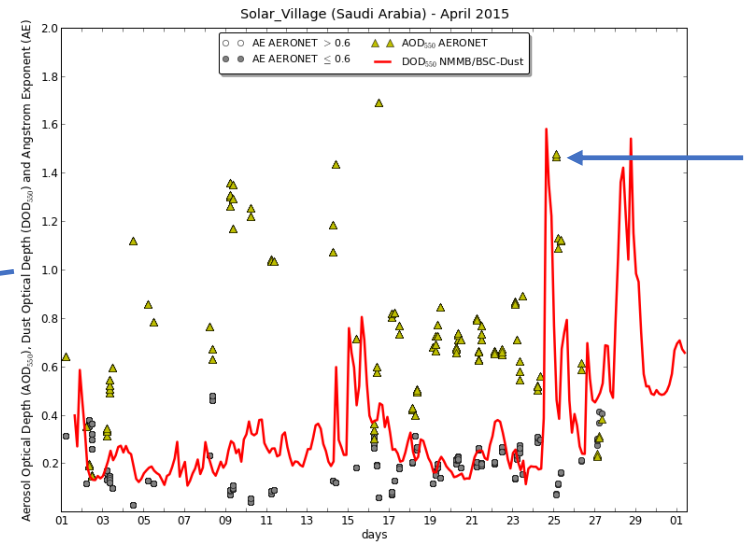
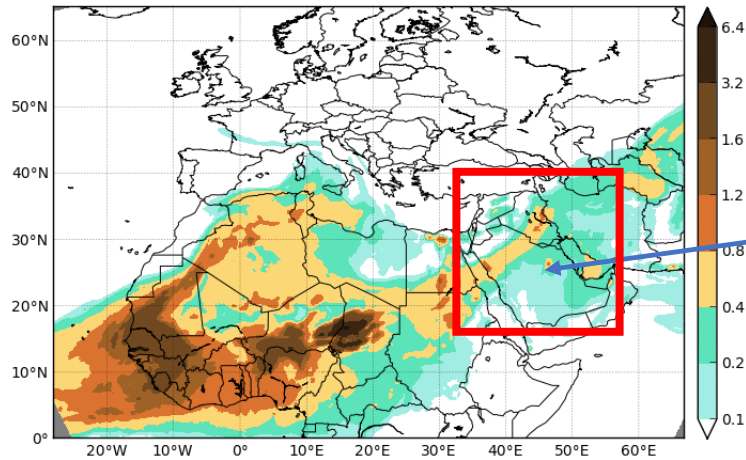
Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 12 FEB 2015 Valid: 12h 12 FEB 2015 (H+00)



<http://dust.aemet.es/>

BDFC: Dust event Middle East Apr 2015

Barcelona Dust Forecast Center
NMMB/BSC-Dust Res:0.1°x0.1° Dust AOD
Run: 12h 23 APR 2015 Valid: 12h 23 APR 2015 (H+00)



Summary

Ongoing **NMMB/BSC-Dust** model developments to improve the quality of daily dust forecast includes:

- Data assimilation of satellite aerosol products for mineral dust analysis
- Exploration of the advantages of the high-resolution simulations (> 4km spatial horizontal resolution) → Dust sources, haboobs and complex terrains

Ongoing activities of the **WMO Dust Centers** includes:

- **Dust model evaluation** including data from satellites, and lidar, Sun-photometer and in-situ networks covering multiple time-scales
- Increased education and awareness to promote the information and forecasts that are publically and freely available
- Establishment of appropriate communication channels for the dissemination of interpreted dust forecasts at a frequency that enables preparedness (i.e. through weather news networks, text message alerts)



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Mineral Dust Modelling

Historical evolution

